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STRUCTURAL MATERIALS & DEVELOPMENT

ADVANCED COMPOSITES TECHNOLOGY

ANISOTROPIC CURVED PANEL ANALYSIS

D. J. Wilkins

Advanced Composites Division
Air Force Materials Laboratory
Wright-Patterson Air Force Base, Ohio

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15 June 1973

Subject: Contract F33615-69-C-1494
Contract Compliance Submittal
General Dynamics Report FZM-5567

To: Air Force Materials Laboratory
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15 May 1973

ANISOTROPIC CURVED PANEL ANALYSIS

Prepared by

Dr. D. J. Wilkins

Prepared for

Advanced Composites Division
Air Force Materials Laboratory
Air Force Systems Command
Wright-Patterson Air Force Base, Ohio

GENERAL DYNAMICS
Convair Aerospace Division
Fort Worth Operation

A B S T R A C T

An analysis of laminated-composite cylindrically curved shells has been formulated and incorporated into digital computer procedure SS8. Many discrete effects were considered, including ring and stringer stiffening, by implementing a Rayleigh-Ritz energy analysis. The procedure solves static deflection, buckling, and natural frequency problems.

The results of an extensive experimental program for graphite-epoxy and boron-epoxy shells are included.

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LIST OF SYMBOLS

| | |
|-----------------|---|
| $[A], [B], [D]$ | Constitutive matrix terms |
| A | Area |
| A_{rk} | Ring cross-sectional area, in^2 . |
| A_{sl} | Stringer cross-sectional area, in^2 . |
| a | Mode shape constants |
| a, b, h | Panel dimensions in (x;y;z) directions |
| C_{mj} | Mode shape constants |
| d | Strain energy partitions defined in Equations (14) - (22) |
| E_1 | Fiber direction elastic modulus |
| E_2 | Transverse direction elastic modulus |
| E_{rk} | Ring modulus of elasticity, psi. |
| E_{sl} | Stringer modulus of elasticity, psi. |
| f | Natural frequency, Hz. |
| G_{12} | In-plane shear modulus |
| $(GJ)_{rk}$ | Ring torsional stiffness, lb-in^2 . |
| $(GJ)_{sl}$ | Stringer torsional stiffness, lb-in^2 . |
| i_x, i_y | Initial modal term in (x;y) direction |
| I_{xxrk} | Moment of inertia of the ring area about the mid-surface x-axis at the line of attachment, in^4 . |
| I_{xzrk} | Product of inertia of the ring area about the mid-surface x-z axis at the line of attachment, in^4 . |
| I_{zzrk} | Moment of inertia of the ring area about the z-axis at the line of attachment, in^4 . |

L I S T O F S Y M B O L S (Continued)

| | |
|---------------------------------------|---|
| $I_{yys\ell}$ | Moment of inertia of the stringer area about the mid-surface y-axis at the line of attachment, in ⁴ . |
| $I_{zzs\ell}$ | Moment of inertia of the stringer area about the z-axis at the line of attachment, in ⁴ . |
| $I_{yzs\ell}$ | Product of inertia of the stringer area about the mid-surface y-z axis at the line of attachment, in ⁴ . |
| K_L | Spring constant, lb/in/in |
| K_P | Spring constant lb/in |
| K_x, K_y, K_{xy} | Curvatures |
| K_{xy} | Proportionality constant (Tables VI and VII) |
| $K_{x1}, K_{x2},$ K_{y1}, K_{y2} | Rotational spring constants, in-lb/rad/in |
| M_L | Line moment, in-lb/in |
| M_P | Point moment, in-lb |
| M_x, M_y, M_{xy} | Moment resultants |
| m | axial mode number |
| \bar{m} | Lumped mass, lb-sec ² /in |
| N_x, N_y, N_{xy} | Stress resultants |
| n | circumferential mode number |
| n_x, n_y | Number of terms in (x;y) direction |
| P | Coefficients defined in Eqs. (30) - (32), lb/in.; load in ring or stringer, lb. |
| P | Pitch (Figure 17) |
| P_c | Point load, lb. |

L I S T O F S Y M B O L S (Continued)

| | |
|----------------|---|
| Q | Potential energy of lateral loads |
| q | Coefficients defined in Eq. (42) |
| \bar{q} | Distributed lateral pressure |
| R | Radius |
| S | Linear part of U_p |
| T | Kinetic Energy |
| U | Potential energy of membrane loads |
| U_p | Total potential energy of membrane loads |
| u, v, w | Displacements in (x;y;z) direction |
| V | Potential energy |
| X, Y | Mode function in (x;y) direction |
| x, y, z | Coordinates in axial, circumferential, and radial directions, respectively. |
| x_k | Ring location |
| \bar{x}_{rk} | Location of ring centroid in the x-direction with respect to its line of attachment to the shell, in. |
| y_l | Stringer location |
| \bar{y}_{sl} | Location of stringer centroid in the y-direction with respect to its line of attachment to the shell, in. |
| \bar{z}_{rk} | Location of ring centroid in the z-direction with respect to the middle surface of the shell at the line of attachment, in. |
| \bar{z}_{sl} | Location of stringer centroid in the z-direction with respect to the middle surface of the shell at the line of attachment, in. |

L I S T O F S Y M B O L S (Continued)

| | |
|---|--|
| α | Observation angle (Figure 17) |
| α_x, α_y | Constants defined by Equation (97) |
| β_x, β_y | Constants defined by Equation (97) |
| γ | Knockdown factor |
| δ | Distance defined in Figure 17 |
| $\epsilon_x^0, \epsilon_y^0, \epsilon_{xy}^0$ | Midsurface strain |
| λ | Buckling eigenvalue |
| ν_{12} | Major Poisson's ratio |
| ρ | Density |
| ρ_{jm} | Mode shape functions |
| ρ_{rk} | Average density of ring material, lb-sec ² /in ⁴ . |
| ρ_{sl} | Average density of stringer material, lb-sec ² /in ⁴ . |
| τ | Time; shear stress |
| ϕ | Integrals defined by Equation (105) |
| ψ | Integrals defined by Equation (102) |
| Ω | Integrals defined by Equation (104) |
| ω | Circular frequency |

SECTION I

INTRODUCTION

Modern aircraft are constructed with many curved panels. In the past, the use of isotropic materials permitted a relatively small number of tests to be used in the generation of simplified analytical methods and design curves. The advent of high-performance laminated composites has required the development of improved analysis tools since material properties of composites have defied simplification and their various coupling effects are often unconservative.

Ashton [1] has shown that the Rayleigh-Ritz method, when properly formulated and coupled with an efficient method of calculating the necessary integrals, can be a very versatile and efficient tool for structural analysis.

Consequently, an analysis tool for cylindrically curved anisotropic panels was proposed. The resulting program includes the following capabilities:

A. Types of Analysis

1. Static deflection and strength under complicated variations of edge and lateral loads with complicated support conditions
2. Elastic stability under complicated edge loads
3. Natural frequencies and mode shapes.

B. Geometry

1. Flat panel
2. Cylindrically curved panel
3. Full cylinder (specially orthotropic only).

C. Construction

1. Sheet with discrete rings and stringers
2. Sandwich with discrete rings and stringers (neglecting core shear).

D. Material - Linearly Elastic

1. Panel - layered anisotropic
2. Stiffeners - orthotropic.

E. Boundary Conditions

1. All combinations of clamped and simply supported;
some combinations with free edges
2. Elastic moment restraint on opposite edges.

The analytical approach and the documentation of most of the required derivations is given in Section II. Other detailed derivations and assumptions are explained under the appropriate subroutine titles in the computer program documentation.

SECTION II

ANALYTICAL FORMULATION

2.1 METHOD OF ANALYSIS

The Rayleigh-Ritz energy method has been chosen for the analysis because of its versatility and speed when compared to finite-element or finite-difference techniques. Many effects may be considered by simply adding their contributions to the total energy of the system, without increasing the size of the resulting set of equations.

The basic energy principle involved is the theorem of stationary potential energy. In the present case it may be written as

$$V + U + Q - T = \text{constant} \quad (1)$$

where

V = strain energy

U = potential energy of membrane loads

Q = potential energy of lateral loads

T = kinetic energy

For a static deflection problem, Equation (1) takes the form

$$V + U + Q = \text{constant} \quad (2)$$

For an elastic stability problem, Equation (1) becomes

$$V + \lambda U = \text{constant} \quad (3)$$

where λ is the buckling eigenvalue.

For a free-vibration problem, including membrane loads, Equation (1) is reduced to

$$V + U - T = \text{constant} \quad (4)$$

These energies are formulated in the following sections. The Rayleigh-Ritz method is then applied to form a set of simultaneous equations for the static deflection problem, or a standard eigenvalue problem for the buckling and vibration cases. This resulting problem is solved with a digital computer program, as described in Appendix I.

All of the following assumptions will be implicit in the analysis:

1. The shell is thin and has constant thickness
2. The displacements are small when compared to the thickness
3. Transverse shear effects are negligible.

2.2 RAYLEIGH-RITZ METHOD

As noted above, each of the problems of concern is governed by Equation (1), where the variations can be replaced with the problem of finding the minimum of Equation (1) by assuming the displacements in the form of a finite series:

$$\begin{aligned} u &= \sum_{m=m_i}^{m_f} \sum_{n=n_i}^{n_f} a_{1mn} X_{1m}(x) Y_{1n}(y) \sin \omega z \\ v &= \sum_{m=m_i}^{m_f} \sum_{n=n_i}^{n_f} a_{2mn} X_{2m}(x) Y_{2n}(y) \sin \omega z \\ w &= \sum_{m=m_i}^{m_f} \sum_{n=n_i}^{n_f} a_{3mn} X_{3m}(x) Y_{3n}(y) \sin \omega z \end{aligned} \quad (5)$$

where

$$m_i = i_x \quad ; \quad m_f = i_x + n_x - 1$$

$$n_i = i_y \quad ; \quad n_f = i_y + n_y - 1$$

the a_{1mn} are undetermined constants, and the functions X_{1m} , Y_{1n} are chosen to satisfy the geometric boundary conditions on u , v , and w . Introducing the assumed series into Equation (1) reduces the problem to finding the minimum of Equation (1) with respect to the undetermined constants, a_{1mn} . Thus, Equation (1) is now a function of only the undetermined constants, a_{1mn} , and is equivalent to the following conditions:

$$\frac{\partial}{\partial a_{imn}} (V+U+Q-T) = 0 \quad (6)$$

where $i = 1, 2, 3$; $m = m_1, \dots, m_f$; $n = n_1, \dots, n_f$; such that Equation (6) denotes a set of $3 n_x n_y$ simultaneous algebraic equations, for which solution techniques are readily available.

The assumed series (5) always involve additional constraints on the energy criteria beyond the physical constraints on the problem, so that the solution obtained by the Rayleigh-Ritz method is always in the direction of a stiffer structure. However, if the assumed series is complete and satisfies the geometric boundary conditions, then the consecutive solutions obtained by including additional terms in the assumed series must approach the correct solution.

2.3 SHELL THEORY

Before proceeding with the analysis, a set of equations defining the midsurface strains and curvatures in terms of the deflections u , v , and w are required. These strain-displacement relations constitute the shell theory being used. Several theories are commonly used, namely Love's, Donnell's, Novozhilov's, etc. In this work, Vlasov [2] shell theory will be used. In the present notation, it requires that

$$\begin{aligned} \epsilon_x^0 &= u_{,x} \\ \epsilon_y^0 &= v_{,y} + w/R \\ \epsilon_{xy}^0 &= u_{,y} + v_{,x} \\ K_x &= -w_{,xx} \\ K_y &= -w_{,yy} - R^{-2}w \\ K_{xy} &= -2w_{,xy} - R^{-1}u_{,y} + R^{-1}v_{,x} \end{aligned} \quad (7)$$

where the commas denote partial differentiation with respect to the variables following them; the coordinate system and sign conventions are shown in Figures 1 and 2.

With the definitions of Equation (7), the total strain at any point at a distance z from the middle surface is written as

$$\begin{aligned}\epsilon_x &= \epsilon_x^0 + z K_x \\ \epsilon_y &= \epsilon_y^0 + z K_y \\ \epsilon_{xy} &= \epsilon_{xy}^0 + z K_{xy}\end{aligned}\tag{8}$$

2.4 SHELL STRAIN ENERGY

The derivation of the shell strain energy is necessary for all three of the analyses to be performed. The derivation depends on the coordinate system and sign conventions shown in Figures 1 and 2.

For a laminated anisotropic material, the constitutive relations [3] are

$$\begin{bmatrix} N_x \\ N_y \\ N_{xy} \\ M_x \\ M_y \\ M_{xy} \end{bmatrix} = \begin{bmatrix} A_{11} & A_{12} & A_{16} & B_{11} & B_{12} & B_{16} \\ A_{12} & A_{22} & A_{26} & B_{12} & B_{22} & B_{26} \\ A_{16} & A_{26} & A_{66} & B_{16} & B_{26} & B_{66} \\ B_{11} & B_{12} & B_{16} & D_{11} & D_{12} & D_{16} \\ B_{12} & B_{22} & B_{26} & D_{12} & D_{22} & D_{26} \\ B_{16} & B_{26} & B_{66} & D_{16} & D_{26} & D_{66} \end{bmatrix} \begin{bmatrix} \epsilon_x^0 \\ \epsilon_y^0 \\ \epsilon_{xy}^0 \\ K_x \\ K_y \\ K_{xy} \end{bmatrix}\tag{9}$$

which includes bending-stretching coupling, as well as coupling between normal stress, shearing and twisting deformations.

The strain energy of the shell may be concisely stated as

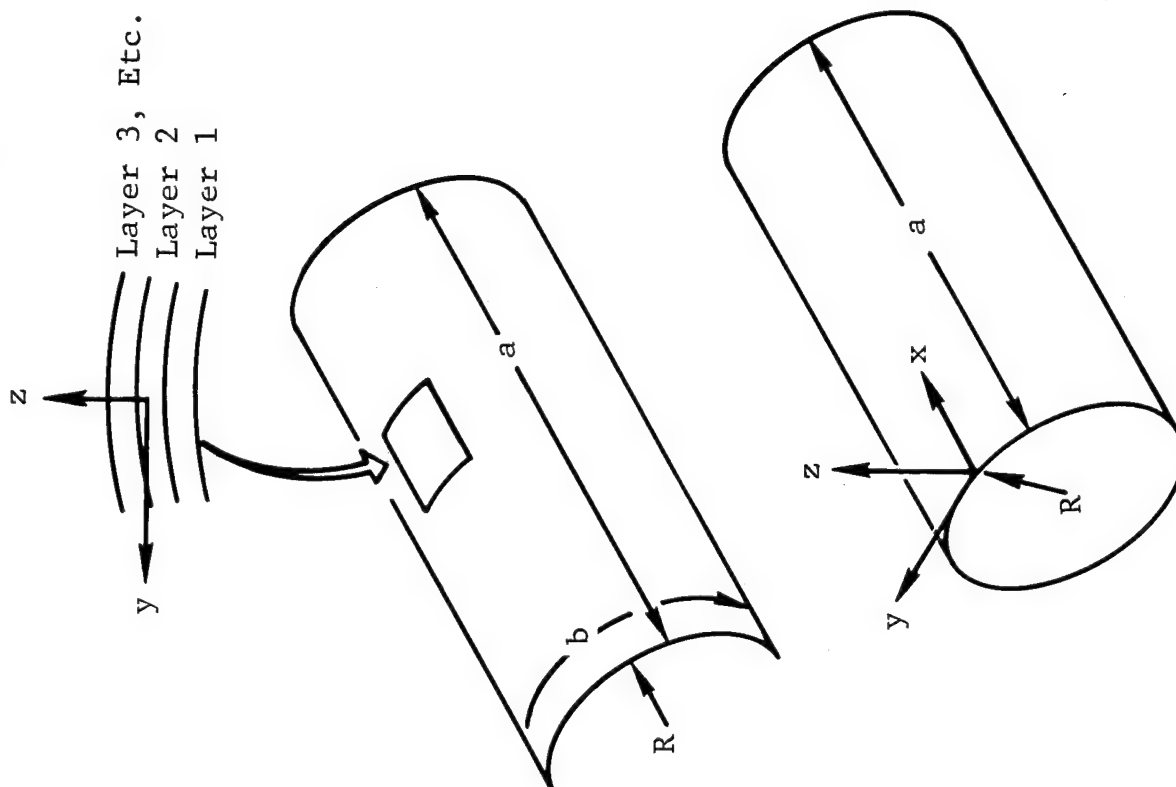


Figure 1 Shell Geometry

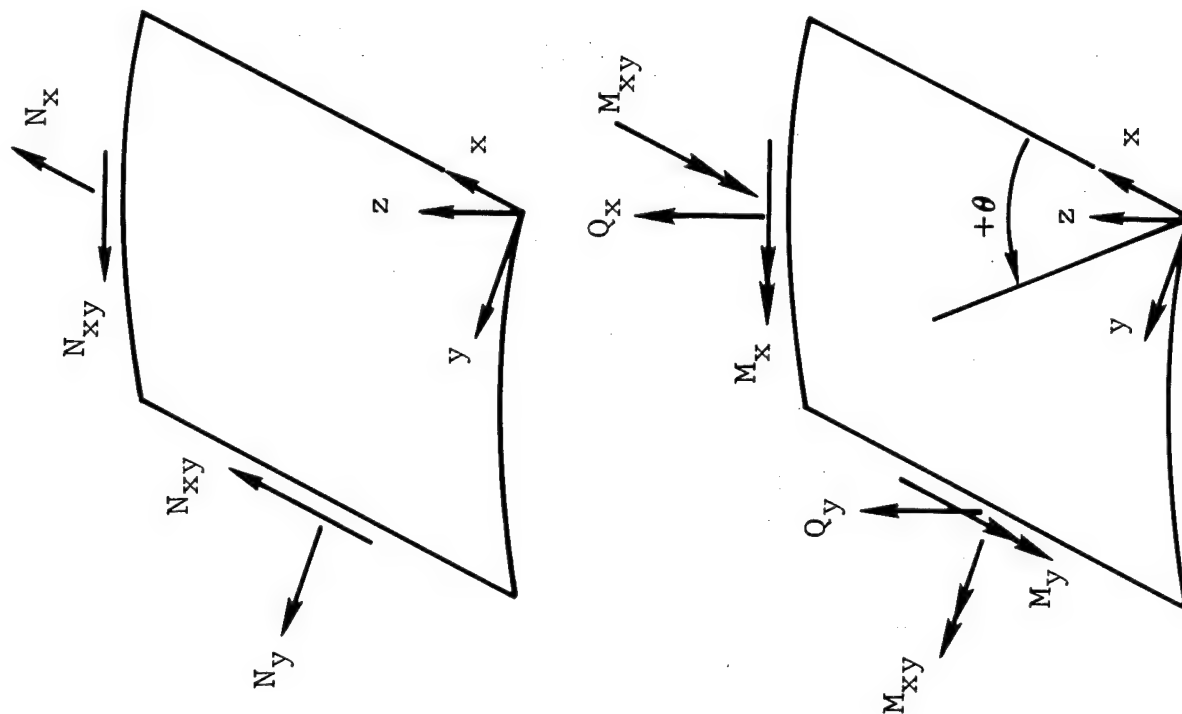


Figure 2 Sign Convention for Positive Loads

$$V_S = \frac{1}{2} \iint_A \begin{Bmatrix} N \\ M \end{Bmatrix}^T \begin{Bmatrix} \epsilon^0 \\ K \end{Bmatrix} dA \quad (10)$$

which, after substituting from Equation (9), takes the form

$$V_S = \frac{1}{2} \iint_{\text{Area}} \{ \epsilon^0 \}^T [A] \{ \epsilon^0 \} + 2 \{ \epsilon^0 \}^T [B] \{ K \} + \{ K \}^T [D] \{ K \} dA \quad (11)$$

Using Equations (7) and (9) and performing the indicated matrix operations in Equation (11) results in the following:

$$\begin{aligned} V_S = & \frac{1}{2} \iint_A A_{11} [u_{,x}^2] + 2A_{12} [u_{,x} u_{,y} + \bar{R}^{-1} u_{,x} w] \\ & + 2A_{16} [u_{,x} u_{,y} + u_{,x} v_{,x}] + A_{22} [v_{,y} + \bar{R}^{-1} w]^2 \\ & + 2A_{26} [u_{,y} v_{,y} + v_{,x} v_{,y} + \bar{R}^{-1} u_{,y} w + \bar{R}^{-1} v_{,x} w] + A_{66} [u_{,y} + v_{,x}]^2 \\ & - 2B_{11} [u_{,x} w_{,xx}] - 2B_{12} [v_{,y} w_{,xx} + \bar{R}^{-1} w w_{,xx} + u_{,x} w_{,yy} - \bar{R}^{-2} u_{,x} w] \\ & + 2B_{16} [\bar{R}^{-1} u_{,x} v_{,x} - u_{,y} w_{,xx} - v_{,x} w_{,xx} - 2u_{,x} w_{,xy} - \bar{R}^{-1} u_{,x} u_{,y}] \\ & - 2B_{22} [v_{,y} w_{,yy} + \bar{R}^{-1} w w_{,yy} + \bar{R}^{-2} v_{,y} w + \bar{R}^{-3} w^2] \\ & + 2B_{26} [\bar{R}^{-1} v_{,x} v_{,y} - u_{,y} w_{,yy} - v_{,x} w_{,yy} - 2v_{,y} w_{,xy} - 2\bar{R}^{-1} w w_{,xy} \\ & - \bar{R}^{-1} u_{,y} v_{,y} - 2\bar{R}^{-2} u_{,y} w] + 2B_{66} [\bar{R}^{-1} v_{,x}^2 - 2u_{,y} w_{,xy} - 2v_{,x} w_{,xy} \\ & - \bar{R}^{-1} u_{,y}^2] + D_{11} [w_{,xx}^2] + 2D_{12} [w_{,xx} w_{,yy} + \bar{R}^{-2} w w_{,xx}] \\ & + 2D_{16} [2w_{,xx} w_{,xy} + \bar{R}^{-1} u_{,y} w_{,xx} - \bar{R}^{-1} v_{,x} w_{,xx}] \end{aligned} \quad (12)$$

$$\begin{aligned}
& + D_{22} [2\bar{R}^2 w_{,yy} + \bar{R}^4 w^2 + w_{,yy}^2] + 2D_{26} [2w_{,xy} w_{,yy} \\
& + \bar{R}^1 u_{,y} w_{,yy} - \bar{R}^1 v_{,x} w_{,yy} + 2\bar{R}^2 w w_{,xy} + \bar{R}^3 u_{,y} w - \bar{R}^3 v_{,x} w] \\
& + D_{66} [4\bar{R}^1 u_{,y} w_{,xy} - 4\bar{R}^1 v_{,x} w_{,xy} - 2\bar{R}^2 u_{,y} v_{,x} + \bar{R}^2 u_{,y}^2 \\
& + \bar{R}^2 v_{,x}^2 + 4w_{,xy}^2] \quad d(\text{Area})
\end{aligned}$$

Substitution of Equation (5) into Equation (12), non-dimensionalization of the shape functions, taking partial derivatives with respect to the undetermined constants, and defining the integral functions ψ gives

$$\frac{\partial V_3}{\partial a_{kij}} = \sum_{l=1}^3 \sum_{n=m_i}^{n_f} \sum_{n=n_i}^{n_f} d_{kl ijmn} a_{lmn} \quad \begin{cases} k=1,2,3 \\ i=m_i, \dots, m_f \\ j=n_i, \dots, n_f \end{cases} \quad (13)$$

where

$$\begin{aligned}
d_{11 ijmn} = & A_{11} \bar{a} \bar{b} [\psi_{x2i1im} \psi_{y11jin}] + (A_{16} - B_{16} \bar{R}^1) [\psi_{x4iim} \cdot \\
& \psi_{y41n1j} + \psi_{x41m1i} \psi_{y41jin}] + \bar{a} \bar{b}^1 (A_{66} - 2B_{66} \bar{R}^1 \\
& + D_{66} \bar{R}^2) [\psi_{x11iim} \psi_{y21jin}]
\end{aligned} \quad (14)$$

$$\begin{aligned}
d_{12 ijmn} = & A_{12} [\psi_{x4i12m} \psi_{y42n1j}] + \bar{a} \bar{b}^1 (A_{16} \\
& + B_{16} \bar{R}^1) [\psi_{x2i12m} \psi_{y11j2n}] + \bar{a} \bar{b}^1 (A_{26} + B_{26} \bar{R}^1) \cdot \\
& [\psi_{x11i2m} \psi_{y21j2n}] + (A_{66} + B_{66} \bar{R}^1) [\psi_{x42m1i} \psi_{y41j2n}]
\end{aligned} \quad (15)$$

$$\begin{aligned}
d_{13ijmn} = & b\bar{R}'(A_{12} - \bar{R}'B_{12})[\psi_{x41i3m}\psi_{y11j3n}] \\
& + a\bar{R}'(A_{26} - 2\bar{R}'B_{26} + \bar{R}^2D_{26})[\psi_{x11i3m}\psi_{y41j3n}] \\
& - B_{11}\bar{a}^2b[\psi_{x63m1i}\psi_{y11j3n}] - B_{12}\bar{b}'[\psi_{x41i3m}\psi_{y53n1j}] \\
& - 2B_{16}\bar{a}'[\psi_{x21i3m}\psi_{y43n1j}] + \bar{a}'(D_{16}\bar{R}' - B_{16})[\psi_{x53m1i} \cdot \\
& \psi_{y41j3n}] + a\bar{b}^2(D_{26}\bar{R}' - B_{26})[\psi_{x11i3m}\psi_{y63n1j}] \\
& + 2\bar{b}'(D_{66}\bar{R}' - B_{66})[\psi_{x43m1i}\psi_{y21j3n}]
\end{aligned} \tag{16}$$

$$\begin{aligned}
d_{22ijmn} = & A_{22}a\bar{b}'[\psi_{x12i2m}\psi_{y22j2n}] + (A_{26} + \bar{R}'B_{26}) \cdot \\
& [\psi_{x42i2m}\psi_{y42n2j} + \psi_{x42m2i}\psi_{y42j2n}] + \bar{a}'b \cdot \\
& (A_{66} + 2\bar{R}'B_{66} + \bar{R}^2D_{66})[\psi_{x22i2m}\psi_{y12j2n}]
\end{aligned} \tag{17}$$

$$\begin{aligned}
d_{23ijmn} = & a\bar{R}'(A_{22} - \bar{R}'B_{22})[\psi_{x12i3m}\psi_{y42j3n}] \\
& - \bar{a}'B_{12}[\psi_{x53m2i}\psi_{y42j3n}] - \bar{a}^2b(B_{16} + \bar{R}'D_{16}) \cdot \\
& [\psi_{x63m2i}\psi_{y12j3n}] + b\bar{R}'(A_{26} - \bar{R}^2D_{26}) \cdot \\
& [\psi_{x42i3m}\psi_{y12j3n}] - a\bar{b}^2B_{22}[\psi_{x12i3m}\psi_{y63n2j}] \\
& - 2\bar{b}'B_{26}[\psi_{x43m2i}\psi_{y22j3n}] - \bar{b}'(B_{26} + \bar{R}'D_{26}) \cdot \\
& [\psi_{x42i3m}\psi_{y53n2j}] - 2\bar{a}'(B_{66} + \bar{R}'D_{66})[\psi_{x22i3m}\psi_{y43n2j}]
\end{aligned} \tag{18}$$

$$\begin{aligned}
d_{33ijmn} = & ab\bar{R}^2(A_{22}-2B_{22}\bar{R}'+D_{22}\bar{R}^{-2})[\psi_{x13i3m}\psi_{y13j3n}] \\
& + \bar{a}'b\bar{R}'(D_{12}\bar{R}'-B_{12})[\psi_{x53i3m}\psi_{y13j3n}+\psi_{x53m3i}\psi_{y13j3n}] \\
& + ab'\bar{R}'(D_{22}\bar{R}'-B_{22})[\psi_{x13i3m}\psi_{y53j3n}+\psi_{x13i3m}\psi_{y53n3j}] \\
& + 2\bar{R}'(D_{26}\bar{R}'-B_{26})[\psi_{x43i3m}\psi_{y43j3n}+\psi_{x43m3i}\psi_{y43n3j}] \\
& + \bar{a}^3bD_{11}[\psi_{x33i3m}\psi_{y13j3n}] \\
& + \bar{a}'\bar{b}'D_{12}[\psi_{x53i3m}\psi_{y53n3j}+\psi_{x53m3i}\psi_{y53j3n}] \\
& + 2\bar{a}^2D_{16}[\psi_{x63i3m}\psi_{y43n3j}+\psi_{x63m3i}\psi_{y43j3n}] \\
& + a\bar{b}^3D_{22}[\psi_{x13i3m}\psi_{y33j3n}] \\
& + 2\bar{b}^2D_{26}[\psi_{x43i3m}\psi_{y63n3j}+\psi_{x43m3i}\psi_{y63j3n}] \\
& + 4\bar{a}'\bar{b}'D_{66}[\psi_{x23i3m}\psi_{y23j3n}]
\end{aligned} \tag{19}$$

The integral functions ψ are defined and explained in Section 2.10. Note also that

$$d_{21ijmn} = d_{12mnij} \tag{20}$$

$$d_{31ijmn} = d_{13mnij} \tag{21}$$

$$d_{32ijmn} = d_{23mnij} \tag{22}$$

so that the potential energy matrix is symmetric.

2.5 SHELL KINETIC ENERGY

The kinetic energy of the vibrating shell is based on the translational inertia in the three coordinate directions. The rotatory inertia components are neglected to maintain consistency with the previous deletion of transverse shear flexibilities. The mass times velocity-squared is written on a differential basis as

$$T = \frac{1}{2} \rho \int_{-z}^z \int_0^b \int_0^a (u_{,z}^2 + v_{,z}^2 + w_{,z}^2) dx dy dz \quad (23)$$

The integral through the thickness is trivial, giving

$$T = \frac{1}{2} \rho h \int_0^b \int_0^a (u_{,z}^2 + v_{,z}^2 + w_{,z}^2) dx dy \quad (24)$$

Performing the same substitution of the assumed modes, taking partials with respect to the undetermined constants, and using the integral definitions as for the potential energy derivations, results in the following required expressions for the variations of the kinetic energy:

$$\frac{\partial T}{\partial a_{1ij}} = \rho h a b \omega^2 \sum_m \sum_n \psi_{x1i1m} \psi_{y1ijn} a_{1mn} \quad (25)$$

$$\frac{\partial T}{\partial a_{2ij}} = \rho h a b \omega^2 \sum_m \sum_n \psi_{x12i2m} \psi_{y12ijn} a_{2mn} \quad (26)$$

$$\frac{\partial T}{\partial a_{3ij}} = \rho h a b \omega^2 \sum_m \sum_n \psi_{x13i3m} \psi_{y13ijn} a_{3mn} \quad (27)$$

2.6 POTENTIAL ENERGY OF INPLANE LOADS

The total potential energy of the inplane loads on a panel may be simply formed as the product of the vector of running loads and the vector of mid-plane strains:

$$U_p = - \iint_A \{N\}^T \{\epsilon\} dA \quad (28)$$

Expanding the strains according to Equation (7) and including first-order nonlinear terms results in

$$U_p = - \iint_A \left\{ N_x [u_{,x} + \frac{1}{2} w_{,x}^2] + N_y [v_{,y} + \bar{R}' w + \frac{1}{2} w_{,y}^2] + N_{xy} [v_{,x} + u_{,y} + w_{,x} w_{,y}] \right\} dA \quad (29)$$

To allow integration of Equation (29) requires an assumed form for N_x , N_y , and N_{xy} . The form assumed here is a power series in the x and y directions, defined as

$$N_x = \sum_{k=1}^{10} \sum_{l=1}^{10} P_{xkl} \left(\frac{x}{a}\right)^{k-1} \left(\frac{y}{b}\right)^{l-1} \quad (30)$$

$$N_y = \sum_{k=1}^{10} \sum_{l=1}^{10} P_{ykl} \left(\frac{x}{a}\right)^{k-1} \left(\frac{y}{b}\right)^{l-1} \quad (31)$$

$$N_{xy} = \sum_{k=1}^{10} \sum_{l=1}^{10} P_{xykl} \left(\frac{x}{a}\right)^{k-1} \left(\frac{y}{b}\right)^{l-1} \quad (32)$$

Before integrating Equation (29), U_p is separated into its linear and nonlinear terms,

$$U_p = S + U \quad (33)$$

where the linear terms are retained in S and the nonlinear terms are retained in U . Then,

$$S = - \iint \sum_k \sum_l \left\{ P_{xkl} [u_{,x}] + P_{ykl} [v_{,y} + w/R] + P_{xykl} [v_{,x} + u_{,y}] \right\} \left(\frac{x}{a}\right)^{k-1} \left(\frac{y}{b}\right)^{l-1} dA \quad (34)$$

Using the definitions of u , v , and w from Equation (5),

$$S = - \iint \sum_k \sum_l \left\{ P_{xkl} \left[\bar{a}' \sum_m \sum_n X_{1m,x} Y_{1n} a_{1mn} \right] + P_{ykl} \left[\bar{b}' \sum_m \sum_n X_{2m} Y_{2n,y} a_{2mn} + \bar{R} \sum_m \sum_n X_{3m} Y_{3n} a_{3mn} \right] + P_{xykl} \left[\bar{a}' \sum_m \sum_n X_{2m,x} Y_{2n} a_{2mn} + \bar{b}' \sum_m \sum_n X_{1m} Y_{1n,y} a_{1mn} \right] \right\} \left(\frac{x}{a}\right)^{k-1} \left(\frac{y}{b}\right)^{l-1} dA \quad (35)$$

Taking partials with respect to the coefficients and using the integral definitions of Section 2.10 gives

$$\frac{\partial S}{\partial a_{1ij}} = - \sum_k \sum_l \left\{ P_{xkl} [b \phi_{kx1i} \phi_{ly1j}] + P_{xykl} [a \phi_{kx1i} \phi_{ly2j}] \right\} \quad (36)$$

$$\frac{\partial S}{\partial a_{2ij}} = - \sum_k \sum_l \left\{ P_{ykl} [a \phi_{kx1i} \phi_{ly2j}] + P_{xykl} [b \phi_{kx2i} \phi_{ky1j}] \right\}$$

$$\frac{\partial S}{\partial a_{3ij}} = - \sum_k \sum_l \left\{ P_{xykl} [ab \bar{R}' \phi_{kx1i} \phi_{ly1j}] \right\}$$

Similarly for U,

$$U = - \iint \sum_k \sum_l \left\{ P_{xkle} \left[\frac{1}{2} w_{,x}^2 \right] + P_{ykle} \left[\frac{1}{2} w_{,y}^2 \right] + P_{xykle} [w_{,x} w_{,y}] \right\} \left(\frac{x}{a} \right)^{k-1} \left(\frac{y}{b} \right)^{l-1} dA \quad (37)$$

Substituting in the definitions of Equation (5), taking partial derivatives and using the integral definitions of Section 2.10 gives

$$\begin{aligned} \frac{\partial U}{\partial a_{ilj}} &= \frac{\partial U}{\partial a_{zij}} = 0 \\ \frac{\partial U}{\partial a_{zij}} &= - \sum_m \sum_n \sum_k \sum_l [a' b P_{xkle} (\Omega_{k1zim} \Omega_{l2ijn}) \\ &\quad + a b' P_{ykle} (\Omega_{k1iim} \Omega_{l22jn}) + P_{xykle} \cdot \\ &\quad (\Omega_{k1zim} \Omega_{l22jn} + \Omega_{k13mi} \Omega_{l22jn})] a_{3mn} \end{aligned} \quad (38)$$

2.7 POTENTIAL ENERGY OF LATERAL LOADS

A distributed lateral pressure is defined by power series in the x and y directions as

$$\bar{q} = \sum_{k=1}^{10} \sum_{l=1}^{10} q_{kle} \left(\frac{x}{a} \right)^{k-1} \left(\frac{y}{b} \right)^{l-1} \quad (39)$$

The potential energy of this load is

$$Q = \iint_A \bar{q} w dA \quad (40)$$

Combination of the definitions for \bar{q} and w , differentiation with respect to the coefficients, and use of the integral definitions results in

$$\frac{\partial Q}{\partial a_{1i}j} = \frac{\partial Q}{\partial a_{2i}j} = 0$$

$$\frac{\partial Q}{\partial a_{3i}j} = \sum_k \sum_l a b g_{kl} \phi_{kx13i} \phi_{ly13j} \quad (41)$$

2.8 DISCRETE ENERGY CONTRIBUTIONS

As noted above, a significant reason for employing the Rayleigh-Ritz energy method is the ease with which many desired effects may be included. These effects and their required energy formulations are described below.

2.8.1 Stiffeners

An important effect to be included for aircraft curved panels is that of discrete, eccentric stiffening elements. These are called stringers in the x-direction and rings in the y-direction.

2.8.1.1 Stringers

The energy contributions for the discrete, eccentric stringers were adapted from Reference [4]. The appropriate geometry for the stiffened shell and the stiffeners themselves is shown in Figures 3 and 4. The potential energy of the stringers due to extension, bending, and torsion, neglecting the bending-torsion coupling, is expressed

$$\Delta V = \sum_{l=1}^L \frac{E_{sl}}{2} \int_0^a \left[(A_{sl} u_{,x}^2 - 2\bar{y}_{sl} A_{sl} u_{,x} v_{,xx} + I_{zzsl} v_{,xx}^2) + I_{yy sl} w_{,xx}^2 - 2\bar{z}_{sl} A_{sl} u_{,x} w_{,xx} + 2I_{yz sl} v_{,xx} w_{,xx} \right] dx + \frac{(GJ)_{sl}}{2} \int_0^a \left. w_{,xy}^2 \right|_{y=y_l} dx \quad (42)$$

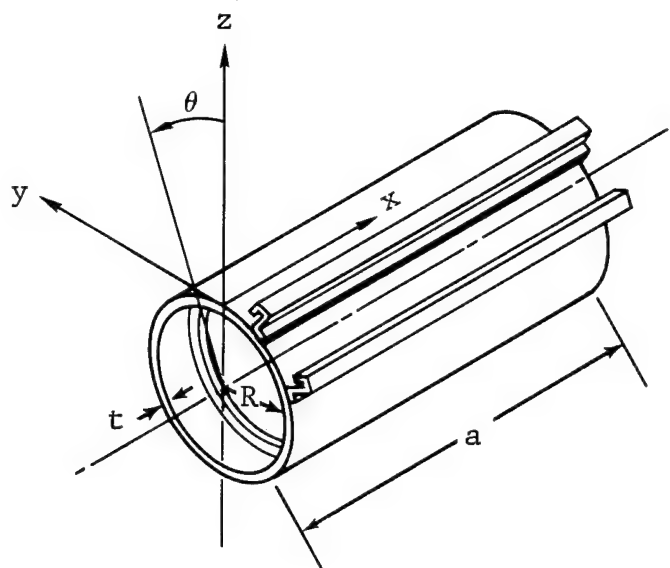


Figure 3 Geometry of Discretely Stiffened Cylinder

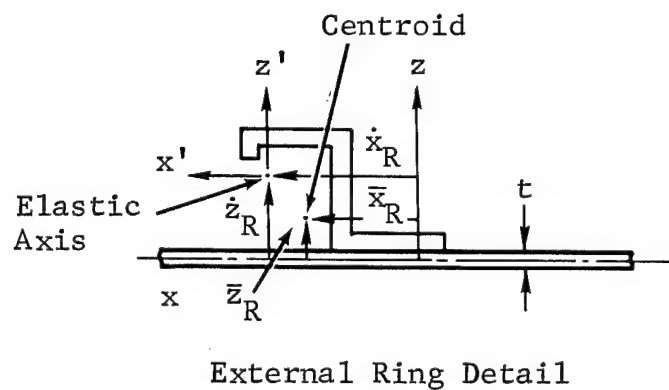
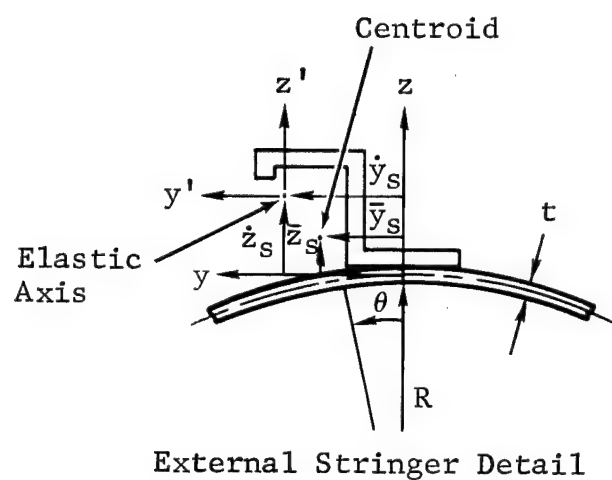


Figure 4 Geometric Detail of Eccentric Stiffeners

The form of the partials after introduction of the assumed modes, nondimensionalization, and integration is

$$\frac{\partial \Delta V}{\partial a_{1ij}} = \sum_{\ell=1}^L \sum_m \sum_n E_{3\ell} A_{3\ell} \left[\bar{a}^1 \psi_{x2i1im} Y_{ij} Y_{in} a_{1mn} - \bar{a}^2 \bar{y}_{3\ell} \psi_{x62mi} Y_{ij} Y_{2n} a_{2mn} - \bar{a}^2 \bar{z}_{3\ell} \psi_{x63mi} Y_{ij} Y_{3n} a_{3mn} \right]_{y=y_\ell} \quad (43)$$

$$\frac{\partial \Delta V}{\partial a_{2ij}} = \sum_{\ell=1}^L \sum_m \sum_n E_{3\ell} \left[-\bar{a}^2 \bar{y}_{3\ell} \psi_{x62im} Y_{2j} Y_{in} a_{1mn} + \bar{a}^3 I_{333\ell} \psi_{x32i2m} Y_{2j} Y_{2n} a_{2mn} + \bar{a}^3 I_{y33\ell} \psi_{x32i3m} Y_{2j} Y_{3n} a_{3mn} \right]_{y=y_\ell} \quad (44)$$

$$\frac{\partial \Delta V}{\partial a_{3ij}} = \sum_{\ell=1}^L \sum_m \sum_n \left\{ E_{3\ell} \left[\bar{a}^3 I_{yy3\ell} \psi_{x33i3m} Y_{3j} Y_{3n} a_{3mn} - \bar{a}^2 \bar{z}_{3\ell} A_{3\ell} \psi_{x63i1m} Y_{3j} Y_{1n} a_{1mn} + \bar{a}^3 I_{y33\ell} \psi_{x33i2m} Y_{3j} Y_{2n} a_{2mn} \right] + \bar{a}^2 (GJ)_{3\ell} \left[\psi_{x23i3m} Y_{3j,1} Y_{3n,1} a_{3mn} \right] \right\}_{y=y_\ell} \quad (45)$$

The stringer kinetic energy is expressed by

$$\Delta T = \frac{1}{2} \sum_{\ell=1}^L \rho_{3\ell} \int_0^a \left[A_{3\ell} (u_{,x}^2 - 2 \bar{y}_{3\ell} u_{,x} v_{,x} + v_{,x}^2 - 2 \bar{z}_{3\ell} u_{,x} w_{,x} - 2 \bar{z}_{3\ell} v_{,x} w_{,x} + w_{,x}^2 + 2 \bar{y}_{3\ell} w_{,x} w_{,y} \right) \quad (46)$$

$$\begin{aligned}
& + I_{zzse} (v_{xz}^2 + w_{yz}^2) + 2 I_{yese} (v_{xz} w_{xz}) \\
& + I_{yyse} (w_{xz}^2 + w_{yz}^2) \Big]_{y=y_e} dx
\end{aligned} \tag{46}$$

Cont'd.

In final form, the partials of the stringer kinetic energy are expressed as

$$\begin{aligned}
\frac{\partial \Delta T}{\partial a_{1ij}} = \sum_{e=1}^L \sum_m \sum_n \rho_{se} \omega^2 A_{se} [a \psi_{x1i1m} Y_{1j} Y_{1n} a_{1mn} \\
- \bar{y}_{se} \psi_{x42m1i} Y_{1j} Y_{2n} a_{2mn} - \bar{z}_{se} \psi_{x43m1i} Y_{1j} Y_{3n} a_{3mn}]_{y=y_e}
\end{aligned} \tag{47}$$

$$\begin{aligned}
\frac{\partial \Delta T}{\partial a_{2ij}} = \sum_{e=1}^L \sum_m \sum_n \rho_{se} \omega^2 \{ [-A_{se} \bar{y}_{se} \psi_{x42i1m} Y_{2j} Y_{1n}] a_{1mn} \\
+ [a A_{se} \psi_{x12i2m} + \bar{a}' I_{zzse} \psi_{x22i2m}] Y_{2j} Y_{2n} a_{2mn} \\
+ [\bar{a}' I_{yyse} \psi_{x22i3m} Y_{2j} Y_{3n} - a \bar{b}' \bar{z}_{se} A_{se} \psi_{x12i3m} Y_{2j} \\
Y_{3n, y}] a_{3mn} \} \Big]_{y=y_e}
\end{aligned} \tag{48}$$

$$\begin{aligned}
\frac{\partial \Delta T}{\partial a_{3ij}} = \sum_{e=1}^L \sum_m \sum_n \rho_{se} \omega^2 \{ [-\bar{z}_{se} A_{se} \psi_{x43i1m} Y_{3j} Y_{1n}] \cdot \\
a_{1mn} + [-\bar{z}_{se} a \bar{b}' A_{se} \psi_{x13i2m} Y_{3j, y} + \bar{a}' I_{yese} \cdot \\
\psi_{x23i2m} Y_{3j}] Y_{2n} a_{2mn} + [(\psi_{x13i3m}) (a A_{se} Y_{3j} \cdot \\
Y_{3n} + a \bar{b}' \bar{y}_{se} A_{se} [Y_{3j} Y_{3n, y} + Y_{3j, y} Y_{3n}] + a \bar{b}^2 Y_{3j, y} \\
Y_{3n, y} [I_{zzse} + I_{yyse}]) + \bar{a}' I_{yyse} \psi_{x23i3m} Y_{3j} Y_{3n}] a_{3mn} \} \Big]_{y=y_e}
\end{aligned} \tag{49}$$

The remaining stringer energy contribution arises from an external axial tension load, P_x , on the stringer. This energy is written

$$\Delta U = - \int_x P_x [u_{,x} - \bar{y}_{se} v_{,xx} - \bar{z}_{se} w_{,xx} + \frac{1}{2} w_{,x}^2] dx \Big|_{y=y_e}^{z=\bar{z}} \quad (50)$$

Putting the linear terms in the S vector and the nonlinear terms in the U matrix, as defined in Section 2.6, gives

$$\frac{\partial \Delta S}{\partial a_{1ij}} = - \sum_{e=1}^L P_{xe} Q_{1xzic} Y_{ij}(y_e) \quad (51)$$

$$\frac{\partial \Delta S}{\partial a_{2ij}} = + \sum_{e=1}^L P_{xe} \bar{a}' \bar{y}_e Q_{1x3zi} Y_{2j}(y_e) \quad (52)$$

$$\frac{\partial \Delta S}{\partial a_{3ij}} = + \sum_{e=1}^L P_{xe} \bar{a}' \bar{z}_e Q_{1x3zi} Y_{3j}(y_e) \quad (53)$$

$$\frac{\partial \Delta U}{\partial a_{1ij}} = \frac{\partial \Delta U}{\partial a_{2ij}} = 0 \quad (54)$$

$$\frac{\partial \Delta U}{\partial a_{3ij}} = - \sum_{e=1}^L \bar{a}' P_{xe} \sum_m \sum_n \psi_{x23i3m} Y_{3j}(y_e) Y_{3m}(y_e) a_{3mn} \quad (55)$$

2.8.1.2 Rings

The energy terms for the discrete, eccentric rings are similar to those for the stringers, but are much more complicated. Reference [4] was also used for these energies; again, refer to Figures 3 and 4.

The potential energy is expressed as

$$\begin{aligned} \Delta V = & \sum_{k=1}^K \frac{E_{rk}}{2} \int_0^b [A_{rk} v_{,y}^2 + I_{xxrk} w_{,yy}^2 + I_{zzrk} u_{,yy}^2 \\ & + \bar{R}^2 A_{rk} w^2 + \bar{R}^2 I_{zzrk} w_{,x}^2 - 2 \bar{z}_{rk} A_{rk} v_{,y} w_{,yy} - 2 \bar{x}_{rk} A_{rk} \cdot \\ & v_{,y} u_{,yy} + 2 \bar{R}^1 A_{rk} v_{,y} w + 2 \bar{R}^1 \bar{x}_{rk} A_{rk} v_{,y} w_{,x} + 2 I_{xxrk} w_{,yy} \cdot \\ & u_{,yy} - 2 \bar{R}^1 \bar{z}_{rk} A_{rk} w_{,yy} w - 2 \bar{R}^1 I_{xxrk} w_{,yy} w_{,x} - 2 \bar{R}^1 \bar{x}_{rk} A_{rk} \cdot \\ & u_{,yy} w - 2 \bar{R}^1 I_{zzrk} u_{,yy} w_{,x} + 2 \bar{R}^2 \bar{x}_{rk} A_{rk} w w_{,x}]_{x=x_k} dy \\ & + \frac{1}{2} (GJ)_{rk} \int_0^b [w_{,xy}^2]_{x=x_k} dy \end{aligned} \quad (56)$$

The final forms of the partials required are

$$\begin{aligned} \frac{\partial \Delta V}{\partial a_{ij}} = & \sum_{k=1}^K \sum_m \sum_n E_{rk} [\bar{b}^3 I_{zzrk} X_{ii} X_{im} \psi_{y3ijm} a_{imn} \\ & - \bar{b}^2 \bar{x}_{rk} A_{rk} X_{ii} X_{2m} \psi_{y6ijm} a_{2mn} + (\bar{b}^3 I_{xxrk} X_{ii} X_{3m} \psi_{y3ijm} \\ & - \bar{x}_{rk} A_{rk} \bar{R}^1 X_{ii} X_{3m} \psi_{y5ijm} - \bar{a}^1 \bar{R}^1 I_{zzrk} X_{ii} X_{3m} \psi_{y5ijm}) \cdot \\ & a_{3mn}]_{x=x_k} \end{aligned} \quad (57)$$

$$\begin{aligned} \frac{\partial \Delta V}{\partial a_{cij}} = & \sum_{k=1}^K \sum_m \sum_n E_{rk} A_{rk} X_{zi} [-\bar{b}^2 \bar{x}_{rk} X_{im} \psi_{y6imej} a_{imn} \\ & + \bar{b}^1 X_{2m} \psi_{y2zjen} a_{2mn} + (-\bar{b}^2 \bar{z}_{rk} X_{3m} \psi_{y63uzj} + \bar{R}^1 X_{3m} \cdot \\ & \psi_{y42j3n} + \bar{a}^1 \bar{R}^1 \bar{x}_{rk} X_{3m} \psi_{y42j3n}) a_{3mn}]_{x=x_k} \end{aligned} \quad (58)$$

$$\begin{aligned}
\frac{\partial \Delta V}{\partial a_{3ij}} = & \sum_{k=1}^K \sum_m \sum_n \left\{ E_{rk} \left[\left(\bar{b}^3 I_{xxrk} X_{3i} X_{1m} \psi_{y33jn} \right. \right. \right. \\
& - \bar{b}^1 \bar{R}' \bar{x}_{rk} A_{rk} X_{3i} X_{1m} \psi_{y51n3j} - \bar{a} \bar{b} \bar{R}' I_{zzrk} X_{3i,x} X_{1m} \cdot \\
& \psi_{y51n3j} \Big) a_{1mn} + \left(-\bar{b}^2 \bar{z}_{rk} A_{rk} X_{3i} X_{2m} \psi_{y63jen} \right. \\
& + \bar{R}' A_{rk} X_{3i} X_{2m} \psi_{y42n3j} + \bar{a} \bar{R}' \bar{x}_{rk} A_{rk} X_{3i,x} X_{2m} \psi_{y42n3j} \Big) \cdot \\
& a_{2mn} + \left(\bar{b}^3 I_{xxrk} X_{3i} X_{3m} \psi_{y33jen} + \bar{b} \bar{R}'^2 A_{rk} X_{3i} X_{3m} \cdot \right. \\
& \psi_{y13jen} + \bar{a}^2 \bar{b} \bar{R}'^2 I_{zzrk} X_{3i,x} X_{3m,x} \psi_{y13jen} - \bar{b}^1 \bar{R}' \bar{z}_{rk} \cdot \\
& A_{rk} X_{3i} X_{3m} \psi_{y53jen} - \bar{b} \bar{R}' \bar{z}_{rk} A_{rk} X_{3i} X_{3m} \psi_{y53n3j} \quad (59) \\
& - \bar{a} \bar{b} \bar{R}' I_{xxrk} X_{3i} X_{3m,x} \psi_{y63jen} - \bar{a} \bar{b} \bar{R}' I_{xxrk} X_{3i,x} X_{3m} \cdot \\
& \psi_{y53n3j} + \bar{a} \bar{b} \bar{x}_{rk} \bar{R}'^2 A_{rk} X_{3i} X_{3m,x} \psi_{y13jen} + \bar{a}^2 \bar{b} \bar{R}'^2 \bar{x}_{rk} \cdot \\
& A_{rk} X_{3i,x} X_{3m} \psi_{y13jen} \Big) a_{3mn} \Big] + \bar{a}^2 \bar{b} (GJ)_{rk} \cdot \\
& \left. \left[X_{3i,x} X_{3m,x} \psi_{y23jen} \right] a_{3mn} \right\}_{x=x_k}
\end{aligned}$$

The kinetic energy of the rings is expressed as

$$\begin{aligned}
\Delta T = & \frac{1}{2} \sum_{k=1}^K \rho_{rk} \int_0^b \left[A_{rk} (u_{,z}^2 - 2 \bar{z}_{rk} u_{,z} w_{,xz} + w_{,xz}^2 \right. \\
& + 2 \bar{x}_{rk} w_{,z} w_{,xz} + v_{,z}^2 - 2 \bar{z}_{rk} v_{,z} w_{,yz} - 2 \bar{x}_{rk} v_{,z} u_{,yz} \Big) \quad (60) \\
& + I_{xxrk} (w_{,xz}^2 + w_{,yz}^2) + 2 I_{xxrk} w_{,yz} u_{,yz} \\
& \left. + I_{zzrk} (w_{,xz}^2 + u_{,yz}^2) \right]_{x=x_k} dy
\end{aligned}$$

The final forms of the ring kinetic energy partial derivatives are

$$\frac{\partial \Delta T}{\partial a_{1ij}} = \sum_{k=1}^K \sum_m \sum_n \rho_{rk} \omega^2 \left\{ [b A_{rk} \psi_{11ijn} + b' I_{22rk} \psi_{21ijn}] \cdot \right. \\ \left. X_{1i} X_{1m} a_{1mn} - \bar{X}_{rk} A_{rk} X_{1i} X_{2m} \psi_{41jzn} a_{2mn} + [-\bar{Z}_{rk} \bar{a}' b A_{rk} \right. \\ \left. X_{3m,x} \psi_{11ijn} + b' I_{22rk} X_{3m} \psi_{21ijn}] X_{1i} a_{3mn} \right\}_{x=x_k} \quad (61)$$

$$\frac{\partial \Delta T}{\partial a_{2ij}} = \sum_{k=1}^K \sum_m \sum_n \rho_{rk} \omega^2 A_{rk} \left\{ [-\bar{X}_{rk} X_{2i} X_{1m} \psi_{41ijn}] a_{1mn} \right. \\ \left. + b X_{2i} X_{2m} \psi_{12jzn} a_{2mn} - \bar{Z}_{rk} X_{2i} X_{3m} \psi_{43jn} a_{3mn} \right\}_{x=x_k} \quad (62)$$

$$\frac{\partial \Delta T}{\partial a_{3ij}} = \sum_{k=1}^K \sum_m \sum_n \rho_{rk} \omega^2 \left\{ [-\bar{a}' b \bar{Z}_{rk} A_{rk} X_{3i,x} \psi_{13ijn} \right. \\ \left. + b' I_{22rk} X_{3i} \psi_{23ijn}] X_{1m} a_{1mn} - [\bar{Z}_{rk} A_{rk} X_{3i} X_{2m} \right. \\ \left. \psi_{43jzn}] a_{2mn} + [(\psi_{13jzn}) (b A_{rk} X_{3i} X_{3m} \right. \\ \left. + \bar{a}' b \bar{X}_{rk} A_{rk} [X_{3i} X_{3m,x} + X_{3i,x} X_{3m}] + \bar{a}^2 b X_{3i,x} \cdot \right. \\ \left. X_{3m,x} [I_{22rk} + I_{22rk}] + b' I_{22rk} X_{3i} X_{3m} \psi_{23ijn}] \cdot \right. \\ \left. a_{3mn} \right\}_{x=x_k} \quad (63)$$

For a panel rather than a complete cylinder, a ring stiffener may support a circumferential load, P_y , imposed at its ends. The energy associated with P_y , which is positive in tension, is given by

$$\Delta U = -b P_y \int_y [b' (v_{,y} - z w_{,yy} - \bar{x} u_{,yy}) + (\bar{R}' w + \bar{R} \bar{x} w_{,x}) \\ + \pm b^2 w_{,y}^2] d\left(\frac{y}{b}\right) \Big|_{x=\bar{x}_k}^{x=\bar{x}_k} \quad (64)$$

After separating into linear and nonlinear terms, as for the stringers, the final partial derivatives are given as

$$\frac{\partial \Delta S}{\partial a_{1i,j}} = - \sum_{k=1}^K P_{yk} \bar{x}_k X_{1i}(x_k) \phi_{1y31j} \quad (65)$$

$$\frac{\partial \Delta S}{\partial a_{2i,j}} = - \sum_{k=1}^K P_{yk} X_{2i}(x_k) \phi_{2y22j} \quad (66)$$

$$\begin{aligned} \frac{\partial \Delta S}{\partial a_{3i,j}} = & - \sum_{k=1}^K P_{yk} \left[-\bar{z}_k X_{3i}(x_k) \phi_{y33j} + b R^{-1} X_{3i}(x_k) \phi_{1y13j} \right. \\ & \left. + b R^{-1} \bar{x}_k X_{3i,x}(x_k) \phi_{1y13j} \right] \end{aligned} \quad (67)$$

$$\frac{\partial \Delta U}{\partial a_{1i,j}} = \frac{\partial \Delta U}{\partial a_{2i,j}} = 0 \quad (68)$$

$$\frac{\partial \Delta U}{\partial a_{3i,j}} = - \sum_{k=1}^K \sum_m \sum_n P_{yk} b^{-1} X_{3i}(x_k) X_{3m}(x_k) \psi_{y23j3n} a_{3mn} \quad (69)$$

2.8.2 Lumped Masses

The kinetic energy contribution of each lumped mass attached to the shell is written in terms of its translational inertia only as

$$\Delta T = \frac{1}{2} \bar{m} (\dot{u}_i^2 + \dot{v}_i^2 + \dot{w}_i^2) \quad (70)$$

In final partial form, after using the assumed mode definitions of u , v , and w ,

$$\frac{\partial \Delta T}{\partial a_{1i,j}} = \bar{m} \omega^2 X_{1i} Y_{1j} \sum_m \sum_n X_{1m} Y_{1n} a_{1mn} \quad \text{at } \phi_{1j} \quad (71)$$

$$\frac{\partial \Delta T}{\partial a_{2ij}} = \bar{m} \omega^2 X_{2i} Y_{2j} \sum_m \sum_n X_{2m} Y_{2n} a_{2mn} \Big|_{\text{pt.}} \quad (72)$$

$$\frac{\partial \Delta T}{\partial a_{3ij}} = \bar{m} \omega^2 X_{3i} Y_{3j} \sum_m \sum_n X_{3m} Y_{3n} a_{3mn} \Big|_{\text{pt.}} \quad (73)$$

2.8.3 Spring Supports

To model nonstandard boundary or internal attachment conditions, it is convenient to have the capability to introduce discrete point and line spring supports.

2.8.3.1 At a Point

Assuming that the spring acts normal to the shell surface, its energy can be defined in terms of w only as

$$\Delta V = \frac{1}{2} K_p w^2 \Big|_{\text{pt.}} \quad (74)$$

The partial derivatives are then trivially formed as

$$\frac{\partial \Delta V}{\partial a_{1ij}} = \frac{\partial \Delta V}{\partial a_{2ij}} = 0 \quad (75)$$

$$\frac{\partial \Delta V}{\partial a_{3ij}} = K_p X_{3i} Y_{3j} \sum_m \sum_n X_{3m} Y_{3n} a_{3mn} \Big|_{\text{pt.}} \quad (76)$$

2.8.3.2 Along a Line

To simplify, it is assumed that the line spring supports lie parallel to either the x - or y -axis of the shell. Then,

$$\Delta V = \begin{cases} \frac{1}{2} K_L a \int_0^1 w^2 d\left(\frac{x}{a}\right) ; & x\text{-axis} \\ \frac{1}{2} K_L b \int_0^1 w^2 d\left(\frac{y}{b}\right) ; & y\text{-axis} \end{cases} \quad (77)$$

After integration and partial differentiation,

$$\frac{\partial \Delta V}{\partial a_{ij}} = \frac{\partial \Delta V}{\partial a_{ji}} = 0 \quad (78)$$

$$\frac{\partial \Delta V}{\partial a_{ji}} = \begin{cases} \sum_m \sum_n K_L a \psi_{x1i3m} Y_{3j} Y_{3m} a_{3m} \Big|_{y=y_0} & ; x\text{-axis} \\ \sum_m \sum_n K_L b X_{3i} X_{3m} \psi_{y13j3m} a_{3m} \Big|_{x=x_0} & ; y\text{-axis} \end{cases} \quad (79)$$

2.8.4 Concentrated Loads

The potential energy of a point load applied normal to the shell surface is written simply as

$$\Delta Q = P_c w \Big|_{\text{pt.}} \quad (80)$$

The final partial form is just as simply written as

$$\frac{\partial \Delta Q}{\partial a_{ij}} = \frac{\partial \Delta Q}{\partial a_{ji}} = 0 \quad (81)$$

$$\frac{\partial \Delta Q}{\partial a_{ji}} = P_c X_{3i} Y_{3j} \Big|_{\text{pt.}} \quad (82)$$

2.8.5 Concentrated Moments

The energy associated with concentrated moment loading is important when input loading from attached members must be assessed. In both point and line moment cases, the vector describing the direction of the moment must be parallel to either the x or y-axis of the shell.

2.8.5.1 At a Point

The energy is formed as the product of the applied moment and the angle through which it is applied

$$\Delta Q = \begin{cases} +M_p (\bar{a}' w_{,x} + \bar{R}' u) & ; \bar{M}_p \text{ in } y\text{-dir.} \\ -M_p (\bar{b}' w_{,y} + \bar{R}' v) & ; \bar{M}_p \text{ in } x\text{-dir.} \end{cases} \quad (83)$$

Substitution of the displacement definitions and partial differentiation of the energy gives

$$\frac{\partial \Delta Q}{\partial a_{i,j}} = \begin{cases} M_p \bar{R}' X_{i,j} Y_{i,j} \Big|_{\text{pt.}} & ; \bar{M}_p \text{ in } y\text{-dir.} \\ 0 & ; \bar{M}_p \text{ in } x\text{-dir.} \end{cases} \quad (84)$$

$$\frac{\partial \Delta Q}{\partial a_{z,i,j}} = \begin{cases} 0 & ; \bar{M}_p \text{ in } y\text{-dir.} \\ -M_p \bar{R}' X_{z,i} Y_{z,j} \Big|_{\text{pt.}} & ; \bar{M}_p \text{ in } x\text{-dir.} \end{cases} \quad (85)$$

$$\frac{\partial \Delta Q}{\partial a_{z,i,j}} = \begin{cases} \bar{a}' M_p X_{z,i,x} Y_{z,j} \Big|_{\text{pt.}} & ; \bar{M}_p \text{ in } y\text{-dir.} \\ -\bar{b}' M_p X_{z,i} Y_{z,j,y} \Big|_{\text{pt.}} & ; \bar{M}_p \text{ in } x\text{-dir.} \end{cases} \quad (86)$$

2.8.5.2 Along a Line

The formation of the energy contribution for line moments is the same as that for point moments except that a line integral is required. The final partials are

$$\frac{\partial \Delta Q}{\partial a_{i,j}} = \begin{cases} M_L \bar{b}' \bar{R}' X_{i,j} \Phi_{i,j} \Big|_{x=x_L} & ; \bar{M}_L \text{ in } y\text{-dir.} \\ 0 & \end{cases} \quad (87)$$

$$\frac{\partial \Delta Q}{\partial a_{z,i,j}} = \begin{cases} 0 & \\ -M_L \bar{a}' \bar{R}' \Phi_{i,z} X_{z,i} Y_{z,j} \Big|_{y=y_L} & ; \bar{M}_L \text{ in } x\text{-dir.} \end{cases} \quad (88)$$

$$\frac{\partial \Delta Q}{\partial a_{3ij}} = \begin{cases} M_L \bar{a}' b X_{3ij} \Phi_{y,3j} \Big|_{x=x_{LM}} ; \bar{M}_L \text{ in } y\text{-Dir.} \\ -M_L \bar{a} b' \Phi_{x,3i} Y_{3j,y} \Big|_{y=y_{LM}} ; \bar{M}_L \text{ in } x\text{-Dir.} \end{cases} \quad (89)$$

2.9 BOUNDARY CONDITIONS

The boundary conditions to be considered are the classical conditions of clamped, simply supported, or free. All combinations of these three may be specified, that is, any edge of a panel may be specified as clamped, supported, or free. In addition, any two opposite edges may have elastic moment restraint. A distinct advantage of the Rayleigh-Ritz method is that only the geometric boundary conditions (displacement and slope) need be satisfied to insure convergence of the solution (although convergence is improved by the satisfaction of the force boundary conditions). The Rayleigh-Ritz method does require a set of assumed modal functions, each of which satisfies the geometric boundary conditions. The functions chosen for this study are a series of simple beam vibration modes. These functions form a complete orthogonal set, and are all of the same general form. The use of these functions allows the normal deflection, w , to satisfy the following conditions:

- (1) clamped edge: $w = 0$; $w, n = 0$
- (2) simply supported edge: $w = 0$; $w,_{nn} = 0$
- (3) free edge: $w,_{nn} = 0$; $w,_{nnn} = 0$
- (4) elastically restrained edge: $w = 0$; $w,_{nn} = \alpha w,_{nn}$

where n denotes a normal to the particular edge.

In addition to these conditions, which apply to flat or curved plates and the ends of a cylinder, the normal deflection in the circumferential direction of a cylinder is taken to be

$$Y_{3n} = \cos \frac{2n\pi y}{b} \quad (90)$$

An assumption has been made concerning the form of u and v . In the x direction, it is assumed that the mode shape function for v is the same as that for w and that the mode shape function for u is the derivative of that for w . Mathematically,

$$\begin{aligned} X_{1m} &= X_{3m,x} \\ X_{2m} &= X_{3m} \end{aligned} \quad (91)$$

Since the roles of u and v are reversed in the y direction, it is also assumed that

$$\begin{aligned} Y_{1n} &= Y_{3n} \\ Y_{2n} &= Y_{3n,y} \end{aligned} \quad (92)$$

These assumptions on the form of u and v allow them to always satisfy their required geometric boundary conditions. The specific form of the assumed modes and the evaluation of the necessary integrals is discussed further in Section 2.10.

In connection with the free-edge boundary condition, it must be noted that no geometric boundary conditions (deflection or slope) on the w displacement are specified. In addition, the force boundary conditions for the free edge of an anisotropic curved panel are so complicated as to be impossible to satisfy with modal functions as simple as beam modes. Thus, while the use of the beam mode functions for a free edge is intuitively acceptable, some difficulties are to be expected.

Often the boundary restraint provided by real structure is between the classical simple support and clamped conditions. Particularly in vibration problems, modeling the actual edge restraint can be important.

The inclusion of elastic moment restraint follows the approach used by Ashton in References [1], [5], and [6]. Basically, a beam mode function having the appropriate frequency and mode shape for the input elastic restraint parameters is calculated (Reference [1]). In addition, the potential energy absorbed by the boundaries must be combined with the usual strain energy.

If the edge restraint moment (in the x -direction) is assumed to be of the form

$$M_x \approx \alpha_x D_u w_{,x} \quad (93)$$

Then the potential energy contribution is of the form

$$\Delta V = \frac{1}{2} \int M_x w_{,x} \quad (94)$$

$$\Delta V = \frac{1}{2} \alpha_x D_{11} \int w_{,x}^2 dx \quad (95)$$

Generalization of this form at both x-edges and both y-edges gives rise to the following approximate potential energy increment:

$$\begin{aligned} \Delta V = \frac{1}{2} D_{11} \left[\alpha_x b \int_0^1 \bar{a}^3 w_{,x}^2 d\left(\frac{y}{b}\right) \Big|_{x=0} + \beta_x b \int_0^1 \bar{a}^3 w_{,x}^2 d\left(\frac{y}{b}\right) \Big|_{x=a} \right] \\ + \frac{1}{2} D_{22} \left[\alpha_y a b^3 \int_0^1 w_{,y}^2 d\left(\frac{x}{a}\right) \Big|_{y=0} + \beta_y a b^3 \int_0^1 w_{,y}^2 d\left(\frac{x}{a}\right) \Big|_{y=b} \right] \end{aligned} \quad (96)$$

where

$$\begin{aligned} \alpha_x &= K_{x1} a / D_{11} \\ \beta_x &= K_{x2} a / D_{11} \\ \alpha_y &= K_{y1} b / D_{22} \\ \beta_y &= K_{y2} b / D_{22} \end{aligned} \quad (97)$$

and K_{x1} , K_{x2} , K_{y1} , K_{y2} are rotational spring constants (in-lb./rad/in) which characterize the support stiffness. The final form of the varied potential energy is

$$\frac{\partial \Delta V}{\partial a_{3ij}} = \frac{\partial \Delta V}{\partial a_{2ij}} = 0 \quad (98)$$

$$\begin{aligned} \frac{\partial \Delta V}{\partial a_{3ij}} = \sum_m \sum_n \left\{ \bar{a}^3 b D_{11} \psi_{y,3j3n} \left[\alpha_x X_{3i,x} X_{3n,x} \Big|_{x=0} + \beta_x X_{3i,x} X_{3n,x} \Big|_{x=a} \right] + a b^3 D_{22} \psi_{x,3i3m} \right. \\ \left. \left[\alpha_y Y_{3j,y} Y_{3n,y} \Big|_{y=0} + \beta_y Y_{3j,y} Y_{3n,y} \Big|_{y=b} \right] \right\} a_{3mn} \end{aligned} \quad (99)$$

2.10 EVALUATION OF INTEGRALS

As shown in Reference [1], the beam mode shapes can be written as a sum of four terms as follows:

$$Z_m(z) = \sum_{j=1}^4 C_{mj} \rho_{jm} \quad (100)$$

where

$$\begin{aligned} \rho_{1m} &= \cosh(\epsilon_m z) \\ \rho_{2m} &= \cos(\epsilon_m z) \\ \rho_{3m} &= \sinh(\epsilon_m z) \\ \rho_{4m} &= \sin(\epsilon_m z) \end{aligned} \quad (101)$$

and the C_{mj} are constants for the particular mode shape m and the appropriate boundary condition. The ϵ_m is the corresponding natural frequency of the m^{th} mode. The C_{mj} constants are tabulated in Reference [1]. The successive derivatives of $Z_m(z)$ are also of this form with changes in the C_{mj} due to the repeating nature of the derivatives of the ρ_{jm} . The z -notation used here is replaced by x or y depending on the plate direction being integrated.

With this special form of the beam mode shapes all of the various integrals may be obtained in a closed form. The detailed solution method is documented in Reference [1].

Since the u and v displacement functions are assumed to be of the same form as w or its derivatives, all of the functions used can be integrated by the same solution technique.

The definition of the integral terms used throughout the analysis to denote the product of two functions is

$$\psi_{z k i j m n} \equiv \int_0^1 Z_{i j, l z} Z_{m n, p z} dz \quad (102)$$

where the k subscript defines the number of derivatives as shown in Table I.

Table I. DEFINITIONS OF ℓ AND p VERSUS k

| GIVEN | DEFINES | |
|-------|---------|-----|
| k | ℓ | p |
| 1 | 0 | 0 |
| 2 | 1 | 1 |
| 3 | 2 | 2 |
| 4 | 1 | 0 |
| 5 | 2 | 0 |
| 6 | 2 | 1 |

For example,

$$\psi_{x4, j3n} = \int_0^1 X_{ij, x} X_{3m} dx. \quad (103)$$

The notation used to denote those integrals in which two w-functions are integrated in the presence of a power term (Section 2.6) is

$$\Omega_{kijmn} \equiv \int_0^1 z^{k-1} Z_{3m, \ell z} Z_{3n, p z} dz \quad (104)$$

where $i = 1$ means that z stands for x and $i = 2$ means that z stands for y . The relationship between j on the left side and ℓ and p on the right side is given by Table II.

Table II. DEFINITIONS OF ℓ AND p VERSUS j

| GIVEN | DEFINED | |
|-------|---------|-----|
| j | ℓ | p |
| 1 | 0 | 0 |
| 2 | 1 | 1 |
| 3 | 1 | 0 |

The notation used to denote a single mode integrated in the presence of a power is given by

$$\phi_{izrgm} \equiv \int_0^1 z^{i-1} Z_{gm,(r-1)z} dz \quad (105)$$

The only integral evaluations involving deviations from the solution format are the rigid body modes necessary for the simple-free and free-free boundary conditions.

For the simple-free case in the x-direction

$$X_{11} = \sqrt{3} \quad (106)$$

$$X_{21} = \sqrt{3} x$$

$$X_{31} = \sqrt{3} x$$

or in the y direction,

$$Y_{11} = \sqrt{3} y \quad (107)$$

$$Y_{21} = \sqrt{3}$$

$$Y_{31} = \sqrt{3} y$$

These mode functions must be combined with the standard form mode functions in a special integral table.

For the free-free boundary condition in the x-direction,

$$X_{11} = 0 \quad X_{12} = -2\sqrt{3}$$

$$X_{21} = 1 \quad X_{22} = \sqrt{3}(1-2x) \quad (108)$$

$$X_{31} = 1 \quad X_{32} = \sqrt{3}(1-2x)$$

or in the y-direction,

$$Y_{11} = 1 \quad Y_{12} = \sqrt{3}(1-2y)$$

$$Y_{21} = 0 \quad Y_{22} = -2\sqrt{3} \quad (109)$$

$$Y_{31} = 1 \quad Y_{32} = \sqrt{3}(1-2y)$$

As in the simple-free case, these mode functions must be combined with the standard form mode function in a special integral table.

SECTION III

ANALYTICAL AND EXPERIMENTAL

CORRELATION

The results of many problem solutions using Procedure SS8 are described in this section. During the development and checkout stages, runs were made to simulate rectangular beams and flat plates. These runs served to debug minor programming errors and build confidence in the solution techniques employed. Subsequent runs were made to compare with existing theoretical and experimental results for isotropic shell segments and cylinders. To test the laminated anisotropic capabilities of the program, it was necessary to perform an experimental test program and to borrow results from on-going composites programs. These tests brought program limitations to light, some of which were overcome and some of which remain.

3.1 STATIC DEFLECTION

The static deflection of an anisotropic plate was checked against Procedure RA5, now revised to be Procedure S00. Agreement was good in all cases. No experimental results for shells could be found, so an experimental program was undertaken.

Two types of tests were performed to assess static deflection capabilities. In performing the first set, done under the Fuselage Program, deflection of fully clamped curved panels under a uniform pressure load was sought. In performing the second set, done under the Dynamic Characteristics Program, Contract F33615-70-C-1837, the determination of the influence coefficients of cantilever curved panels was sought.

3.1.1 Fuselage Program Tests

All of the advanced composite curved plate specimens were laminated graphite-epoxy and fabricated according to drawing number FW6915067. All specimens had the same geometric configuration with respect to length, width and curvature; a sketch of a typical specimen is shown in Figure 5. Average thicknesses and laminate designs of the panels were the physical variables for this program.

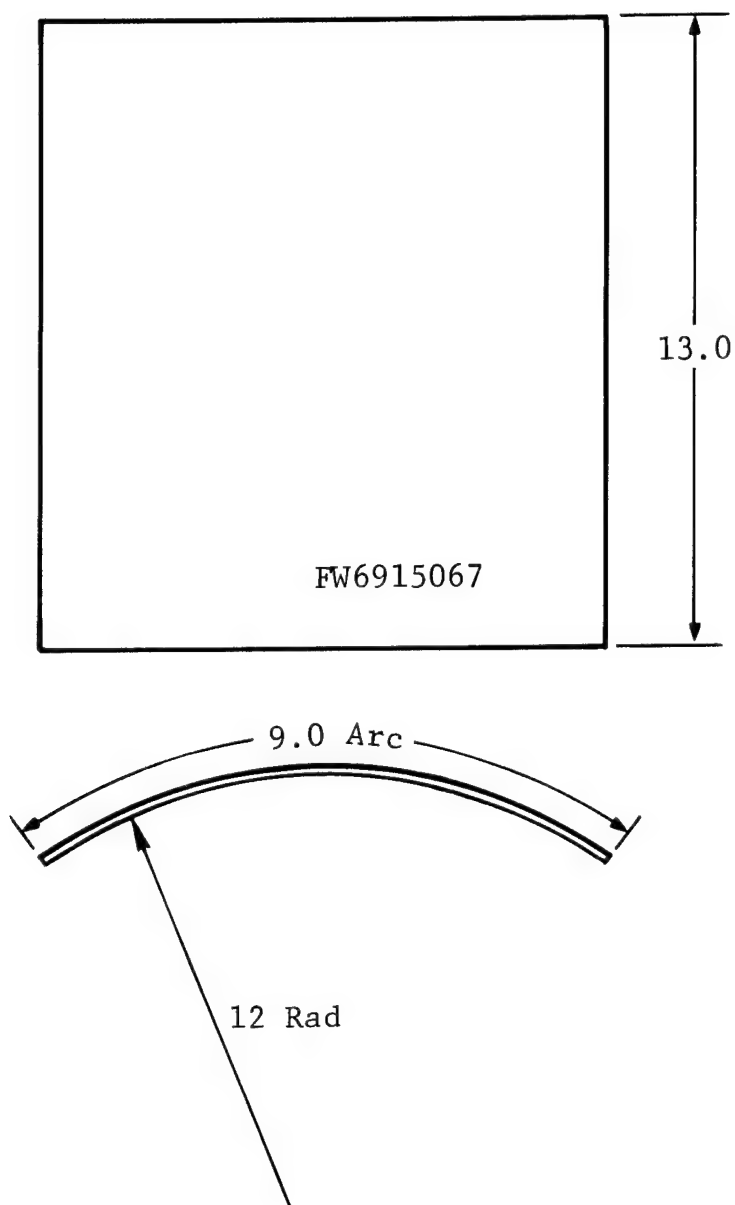


Figure 5 Fuselage Program Curved Panel Specimen Geometry

The specimens were hand-laid using Morganite II/4617 which has lamina properties of

$$E_1 = 20 \times 10^6 \text{ psi}$$

$$E_2 = 2.1 \times 10^6 \text{ psi}$$

$$G_{12} = 0.85 \times 10^6 \text{ psi}$$

$$\nu_{12} = 0.21$$

After their layup on a table, multiple-specimens were draped into a concave steel tool, bagged, and cured. The final operations were to net-trim the straight edges on a specially jugged table saw and net trim the curved edges with an end-mill.

The test fixture was not only used for the lateral pressure tests but was also used for compression buckling and vibration tests. It provided clamped-clamped boundary conditions for the curved edges and either clamped-clamped or simple-simple conditions for the straight edges. Clamping bars provided for variations in thickness of the panels. The test fixture is shown in Figures 6 through 9.

The set-up for the lateral load, or pressure, test utilized a rubber pressure bag mounted against the concave side of the panel. The back side of the bag was reacted with a stiffened pressure plate having the same contour as the panel and bolted to the fixture's side support (see Figures 10 through 13). The size of the bag, when deflated, was sufficient to cover the unsupported area of the panel without creasing or stretching, and thus provided an even load distribution over the face of the panel as air pressure was increased. During the pressure application, the load machine maintained a 100-pound edge load. After preliminary runs using a dial gage, an LVDT instrument measured the out-of-plane deflections as the pressure was increased. Measurements were recorded at increasing pressure increments. For these tests, the panel edges were fully clamped.

The test results and analytical predictions are shown in Table III in terms of center-deflection-per-psi of pressure. The load deflection plots are detailed in Reference [7]. Some analytical results with simply supported straight edges are included in Table III to indicate the sensitivity to boundary conditions. Correlation with elastically restrained edges was not attempted. It is obvious by the poor correlation that the fully clamped boundary condition was not properly modeled in the tests.

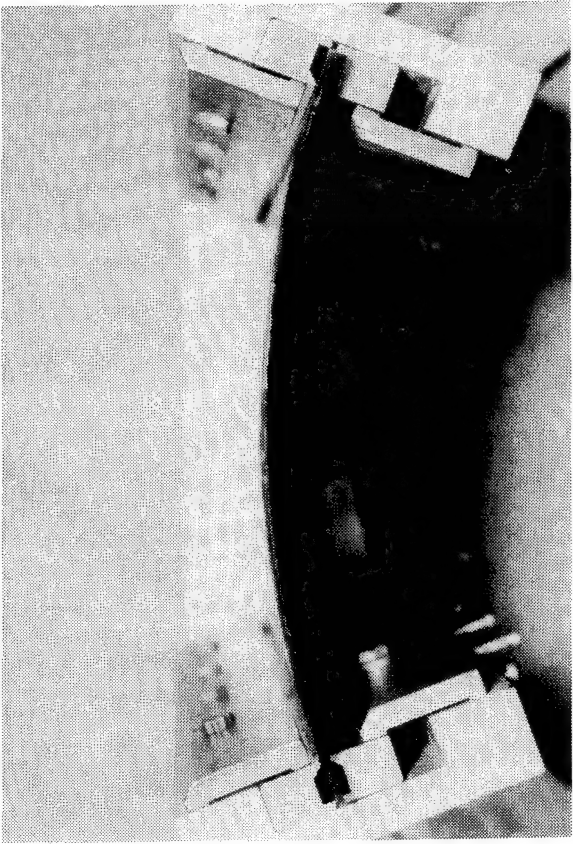


Figure 6 Top View of Test Fixture Showing Simply-Supported Sides

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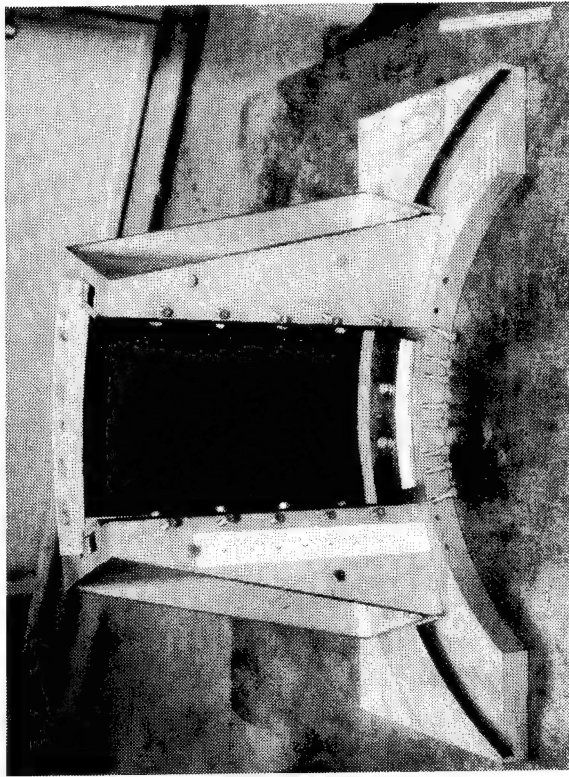


Figure 8 Front View of Test Fixture

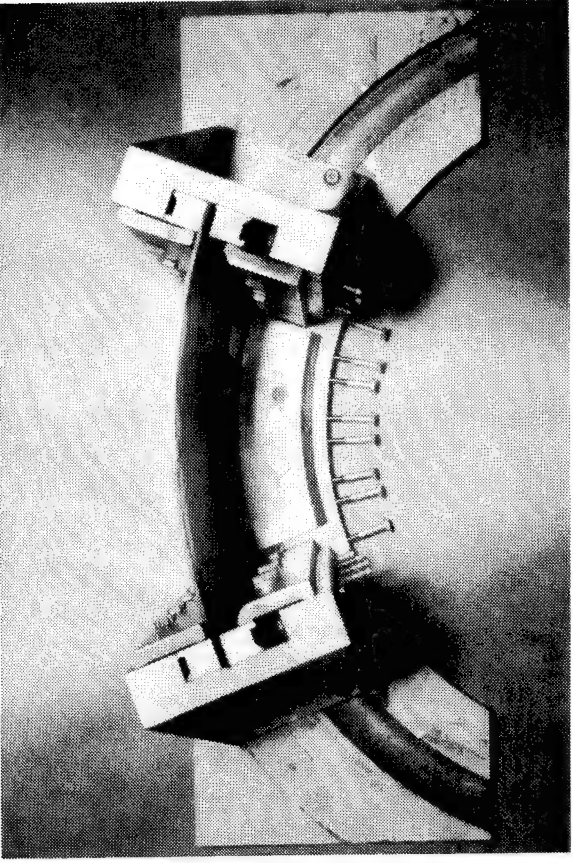


Figure 7 Top View of Test Fixture Showing Clamped Sides

SMD7043

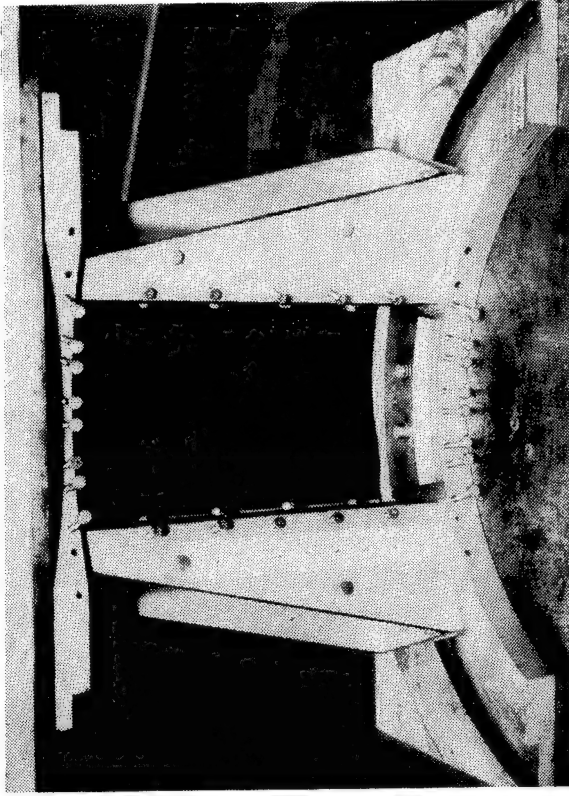


Figure 9 Front View of Test Fixture with Top Support Installed

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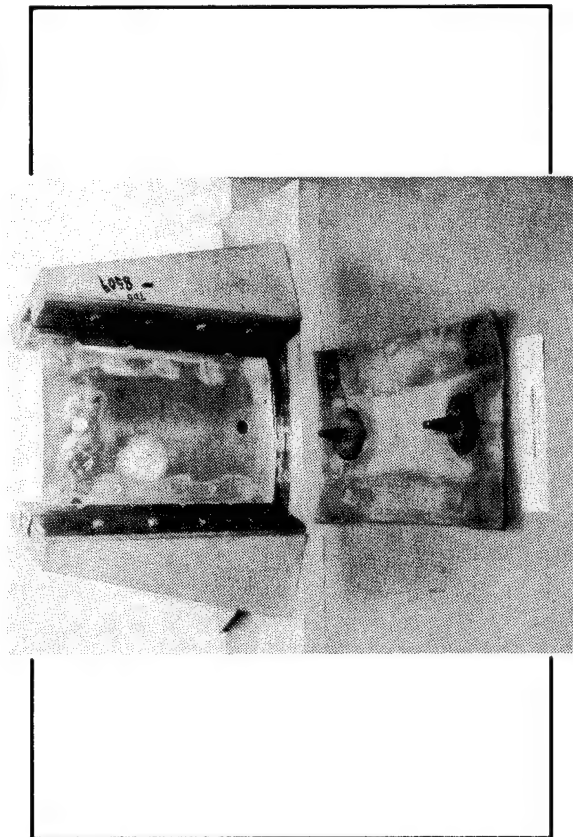


Figure 10 Backup Structure and Pressure Bag

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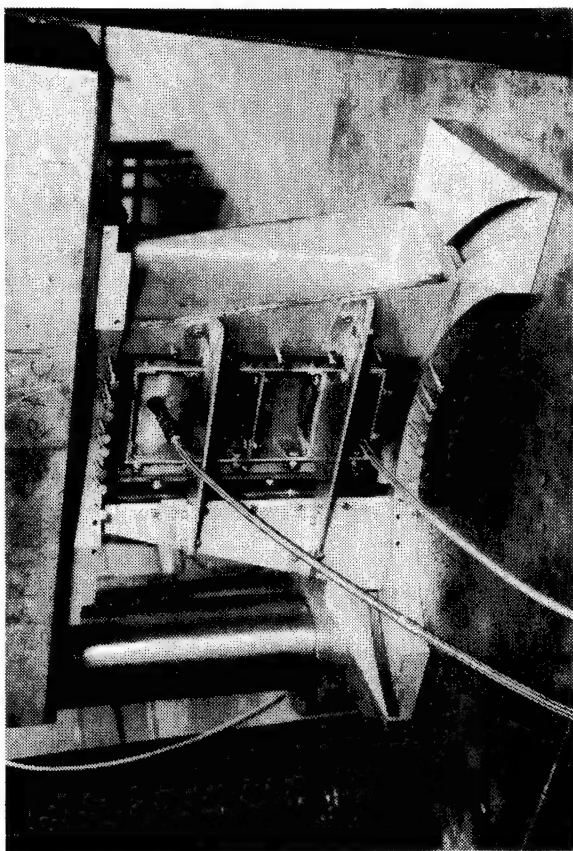


Figure 11 Assembled Pressure Fixture

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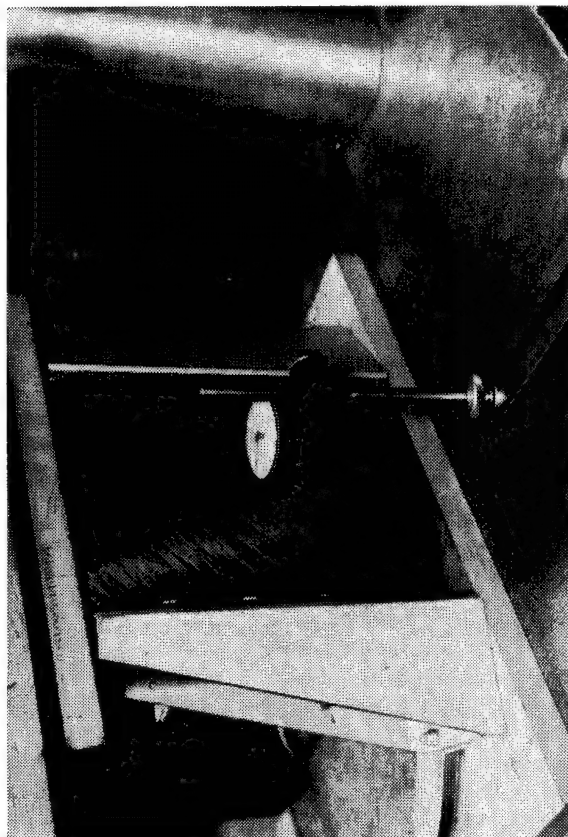


Figure 12 Deflection Measurement Setup

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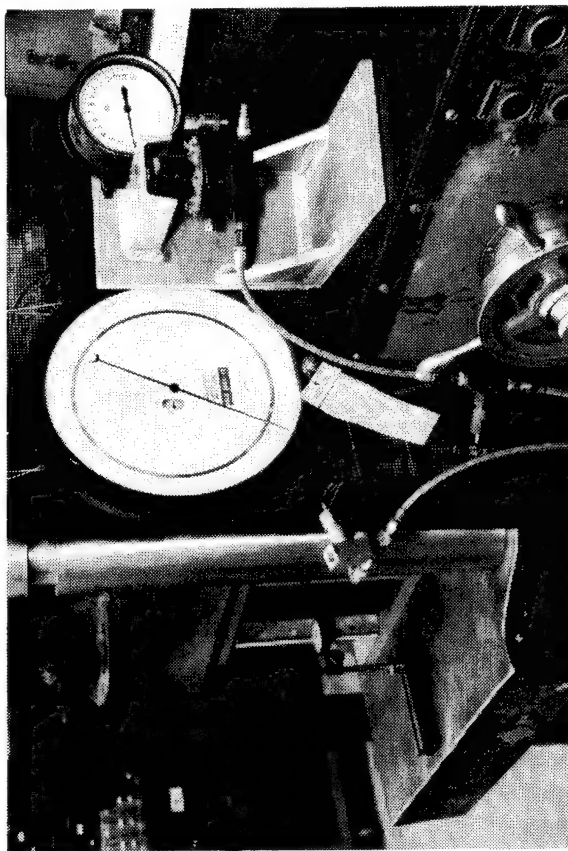


Figure 13 General View of Pressure Test Equipment

Table III PRESSURE TEST RESULTS

| PANEL | LAMINATE | t | W/q mils/psi | | | | |
|-------|-----------------------------|-------|--------------|------|--------|------|--------|
| | | | CCCC | | CCSS | | |
| | | | EXP. | MAX. | CENTER | MAX. | CENTER |
| 19A | [± 45] _{2s} | .0696 | 2.23 | 0.54 | 0.54 | | |
| 19D | [± 45] _{2s} | .0719 | 2.25 | 0.52 | 0.52 | | |
| 21A | [0, 90] _s | .0289 | 9.20 | 0.83 | 0.83 | 36.2 | 5.6 |
| 23E | [± 45] _s | .0307 | 5.01 | 1.25 | 0.89 | | |
| 29E | [± 45] _{3s} | .0892 | 2.63 | 0.43 | 0.43 | | |
| 33E | [± 45] _{4s} | .0591 | 4.8 | 0.67 | 0.67 | 4.3 | 1.6 |
| 35A | [-45] ₁₂ | .0902 | 2.87 | 0.45 | 0.45 | 2.1 | 1.5 |
| 39A | [+30] ₈ | .0580 | 4.70 | 1.35 | 1.29 | 5.2 | 0.44 |
| 41A | [+30] ₁₂ | .0900 | 3.03 | 0.91 | 0.91 | 2.3 | 1.1 |
| 45E | [0] ₈ | .0582 | 6.67 | 2.46 | 2.46 | 13.7 | 7.3 |
| 49A | [0, 90] _{3s} | .0880 | 3.88 | 0.28 | 0.28 | 6.7 | 6.7 |
| 51A | [± 30] _s | .0296 | 7.52 | 2.76 | 1.67 | 19.8 | -7.2 |
| 53A | [± 30] _{2s} | .0557 | 3.16 | 1.27 | 1.23 | 5.1 | -.062 |
| 55A | [± 30] _{4s} | .0807 | 2.40 | 0.97 | 0.97 | 2.4 | .78 |
| 59A | [0, ± 60] _s | .0422 | 3.43 | 0.62 | 0.62 | 8.7 | -1.02 |

3.1.2 Dynamic Characteristics Program Tests

Three curved cantilever panel specimens were designed to study the effect of curvature, in the presence of material anisotropy, on the response of composite structures. The specimens are designated 15, 16A, and 16B and are shown in Figures 14 through 16. All of the curved specimens have 15-inch spans and 24-ply, $[0/\pm 45_4/90]$ laminates. Specimen 15 has a 15-inch chord and a 36-inch radius, while Specimens 16A and 16B have 6-inch chords and 36- and 12-inch radii, respectively. A detailed explanation of these tests is given in Reference [13].

Some difficulty was experienced in conducting influence coefficient testing for the curved panels. A special fixture was developed with which the point loads normal to the undeflected middle surface of the specimen, i.e., in the radial direction, could be applied. Since vertical, free-floating Linear Variable Differential Transformers (LVDT's) were used for deflection measurements, the deflections were not measured radially. The LVDT's were inclined to the vertical as much as possible without compromising the accuracy of the instruments, but they could not be used in the radial direction. The maximum error in deflection caused by this setup was approximately two percent along each edge of the specimen.

Geometric nonlinearities caused by large chordwise cambering deflections were observed in these specimens, particularly in Specimen 15. This was indicated by the lack of symmetry in the off-diagonal terms of the influence coefficients as presented in Table IV. The notation DRR signifies Direct Rayleigh-Ritz, which is SS8. The notation USA denotes Unified Structural Analysis, a finite element procedure. It can be seen in the table that SS8 models the bending stiffness better than the finite element procedure, but does worse for the torsional stiffness. Generally, the correlation was rather poor, but no cause for this could be found. The problem is suspected to be that for these panels the chordwise boundary conditions are free-free, and the free-free modes are not operating properly.

3.2 STABILITY

The stability option of Procedure SS8 is the most important option available to the composites analyst and designer. The fact that composite shells exhibit complicated coupling between material and geometric stiffness effects precludes the use of simple design formulas.

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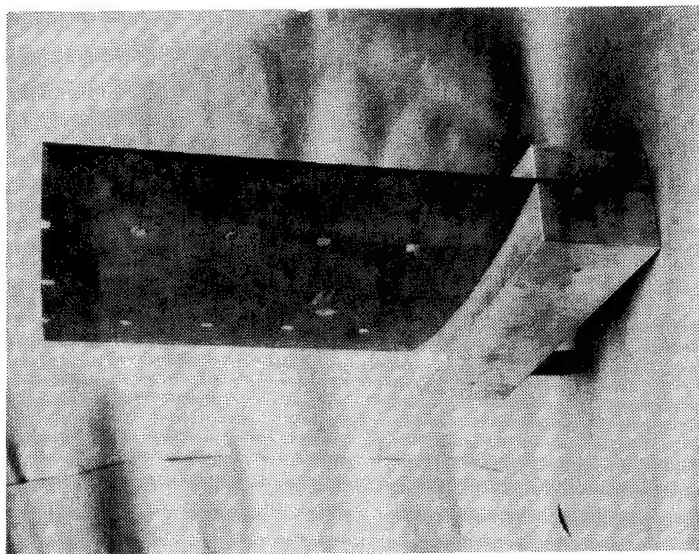


Figure 14 Curved Panel 1 -
Specimen 15

SMD7049

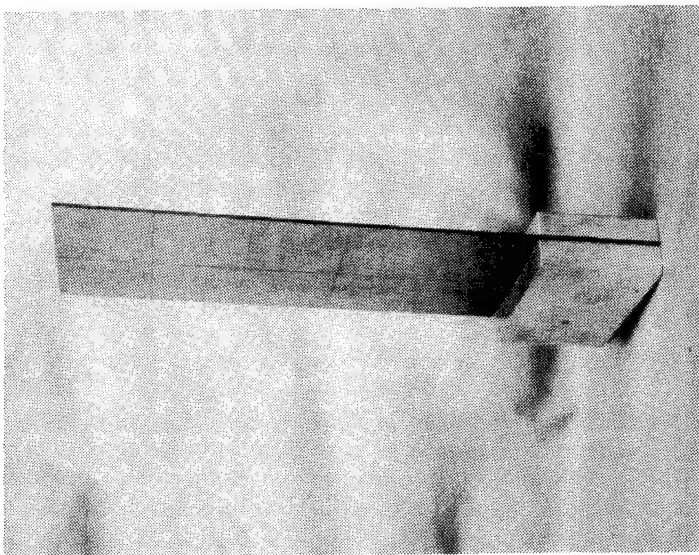


Figure 15 Curved Panel 1 -
Specimen 16A

SMD7050

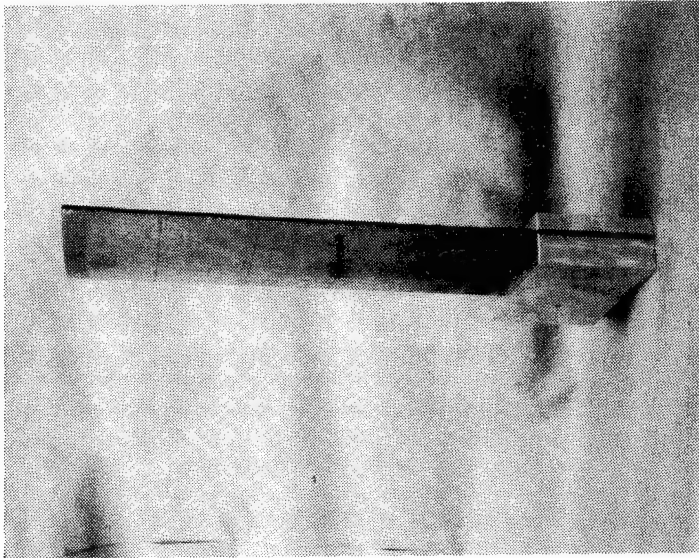


Figure 16 Curved Panel 1 -
Specimen 16B

Table IV FLEXIBILITY MATRIX ELEMENTS FOR

CURVED PANELS

| SPEC. NO. | METHOD | INFLUENCE COEFFICIENTS AT THE TIP (IN./100 LB.) | | | | | | AVERAGE % ERROR |
|--------------|--------|---|---------|---------|----------|----------|----------|--------------------|
| | | a(5,5) | a(5,10) | a(5,15) | a(10,10) | a(10,15) | a(15,15) | |
| 15 | DRR | 0.90 | .077 | -.212 | .200 | .095 | 0.99 | 46.84 |
| | EXP | 1.37 | .126 | -.673 | .242 | .222 | 2.81 | -- |
| 16* | DRR | 18.60 | 16.14 | 13.84 | 14.81 | 13.32 | 12.77 | -- |
| 16A | DRR | 7.60 | 6.51 | 5.56 | 6.26 | 5.85 | 6.11 | 7.57 |
| | USA | 7.64 | 6.05 | 4.77 | 5.61 | 5.07 | 5.42 | 16.15 |
| | EXP | 8.74 | 7.54 | 6.08 | 6.46 | 6.26 | 6.08 | -- |
| 16B | DRR | 1.39 | 1.08 | .846 | 1.18 | 1.16 | 1.49 | 28.60 |
| | USA | 1.58 | 0.863 | .227 | .934 | .951 | 2.04 | 34.44 |
| | EXP | 2.03 | 1.30 | .586 | 1.40 | 1.46 | 2.58 | -- |

*Analysis of 16 as a flat plate for comparison purposes - not a test specimen.

The procedure was checked for composite plate stability with Procedure RA5 and compressive buckling of curved isotropic plates with Timoshenko [8]. Good agreement was obtained in both cases.

Compressive buckling of composite curved plates was correlated with an extensive test series especially instituted for this program. Shear buckling of curved plates was correlated with design development tests for the F-5 fuselage component.

3.2.1 Panel Compression Tests

The test panels and test fixture used in the compression tests were described previously in Section 3.1.1 and are shown in Figures 5-9.

Variations in the panels' curvature and warpage were slight and were corrected upon installation in the rigid loading fixture. Parallelism of loaded edges was determined on installation and corrected, where necessary, prior to a test run (parallelism to 0.003 in. over the edge length was assumed permissible).

Prior to assembly in the test fixture, each panel was bordered with Teflon tape, .003-inch thick, at all points that would be contacted by metal. This reduced the shear loads at the edges that resulted from high friction forces.

The structural similarity of the curved panel specimens was such that a reliable test procedure had to be developed and rigidly adhered to in order to clearly distinguish between the response of the various panels. To aid in this process, the same holding fixture, which accepted various panel thicknesses, was used in all vibration, pressure and buckling tests. A common procedure for installing the panels and aligning the set-up for test runs proved to be highly relevant in obtaining repeatable and satisfactory results. The salient features in installing the panel were to finger-tighten the bolts on the unloaded edge supports when simple support conditions were used, and wrench-tighten (to 60 in.-lb.) the bolts where clamped supports were used. In each case, the bolts were checked after two low-load excursions were applied (these loadings were used to seat the panel and remove most of the hysteresis).

Following the panel installation an axial load was applied using a 120,000-pound Baldwin Universal test machine.

In the buckling test, the information required was out-of-plane movement of the panel as the axial load was increased from 100 pounds to the critical load level. This movement was monitored by two methods: a linear differential transformer whose output was sent to a machine-mounted, x-y drum recorder and by the moire' shadow method.

The moire grid shadow method is an experimental procedure used to measure out-of-plane movements of a surface. Its principal advantage, especially for buckling tests, is that a full-field view of surface movements can be observed as the test progresses. A brief description of how the method works and the equipment used in its application on the panel studies are explained in the following paragraphs. The development of this procedure was based on the information obtained from Reference [9].

The essential pieces of equipment used in developing the moire patterns are a master grid pattern and a rigid transparent backing plate to hold the grid next to the panel. Locations of these elements on a typical test are sketched in Figure 17. In the experiments described in this report, a Kodak Carousel projector for the light source and a mounted plexiglas plate, formed to the same contour as the specimen, to hold the grid pattern in place was used. This is shown in Figures 18 and 19. With this set-up, the grid shadow was obliquely cast on the white surface of the panel. The observer, looking through the master grid, saw two grids superimposed, and as the panel points moved to, or away from, the master grid, the shadowed grid would move up or down by the amount

$$y = \delta \tan \alpha \quad (110)$$

When the panel deflected a distance equal to the pitch, ρ , of the master grid a dark band or fringe would appear. The shape and width of the fringe, as well as the number of fringes seen in an area were, therefore, a function of the change in curvature of the panel over the given area and the grid pitch. For example, a local buckle or a tight hump in the panel would display very narrow and closely spaced fringes, whereas an overall buckle would show very wide fringes which would be spaced far apart. On the other hand, if the grid pitch were halved, the sensitivity of the set-up would be doubled, or, twice as many fringes per unit deflection would be seen. The type of grid originally used in the buckling test was determined by assuming a

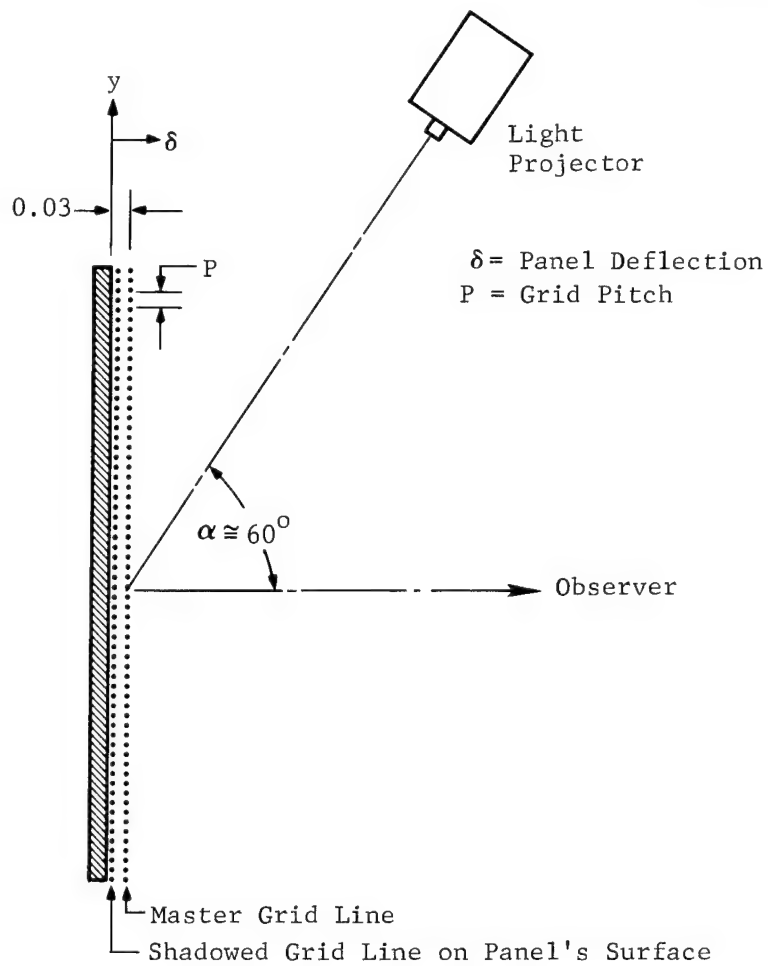


Figure 17 Test Set-Up Using the Moire Grid Shadow Method

SMD7052

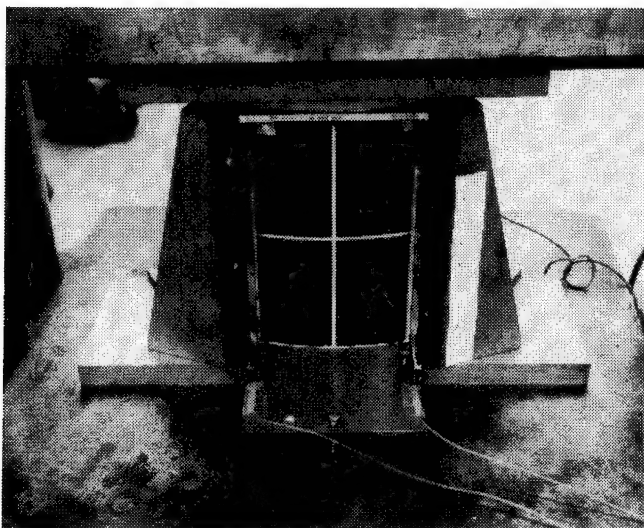


Figure 18 Rear View of Master Grid Plate and Support Structure

SMD7053

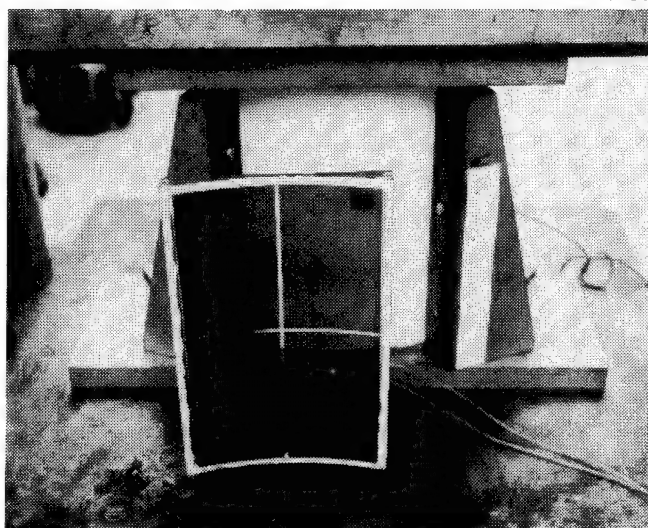


Figure 19 Master Grid as Mounted on Curved Plexiglass Surface

sensitivity of one fringe per 0.01-inch deflection would be desirable. Using the following equation

$$P = \delta \tan \alpha = 0.01 \tan 60^\circ \quad (111)$$

it was determined that 0.017 inch/grid lines, or approximately 50 lines per inch, would be acceptable. Buckling tests with this pattern showed promising results but a need for more sensitivity was required to obtain a better definition of the panel's deflection. Subsequent tests showed that grids having 100 lines/inch gave satisfactory results.

Upon installation, the differential transformer's plunger was lightly spring-loaded against the panel and displaced such that a null balance was achieved at the recorder. The location of the plunger relative to the panel was established by viewing the movements of the moire fringe pattern on the opposite face during the initial loadings. The area having the greatest fringe shift indicated the most out-of-plane activity, thus locating the plunger to obtain maximum deflections.

The moire patterns, which were developed on the white surface of the painted panel, were used to stop the loading when buckling was observed to be imminent. The characteristics of the pattern at this point were rapid fringe movement and the decreasing distance between adjacent fringes. When these conditions occurred, the load was immediately dumped and the maximum load attained was recorded.

The test setup and some representative moire photographs are shown in Figures 20 through 25. Many more photos are shown in Reference [7].

During the time the moire patterns were being observed, a simultaneous plot of the out-of-plane motion at an established point on the opposite panel face was made. This plot of deflection vs. load was provided by the test machine's integral recording system. These curves, an example of which is shown in Figure 26, were used to obtain Southwell plots (see Figure 27) which ultimately provided the critical buckling load of the panel. All Southwell plots are shown in Reference [7]. The Southwell method is a technique for obtaining the buckling load of a structure from experimental load-deflection information. The details of its implementation differ depending on the structure being

SMD7054

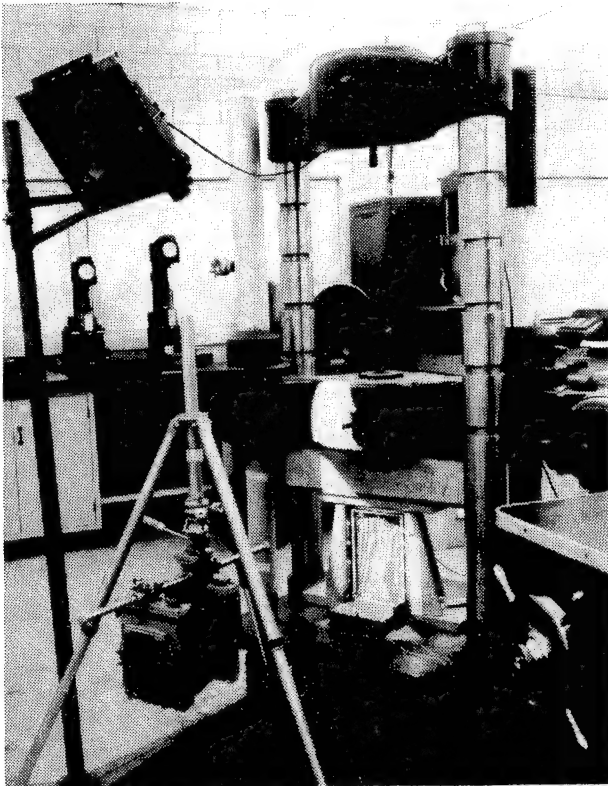


Figure 20 Test Setup for
Buckling Investigation

SMD7055

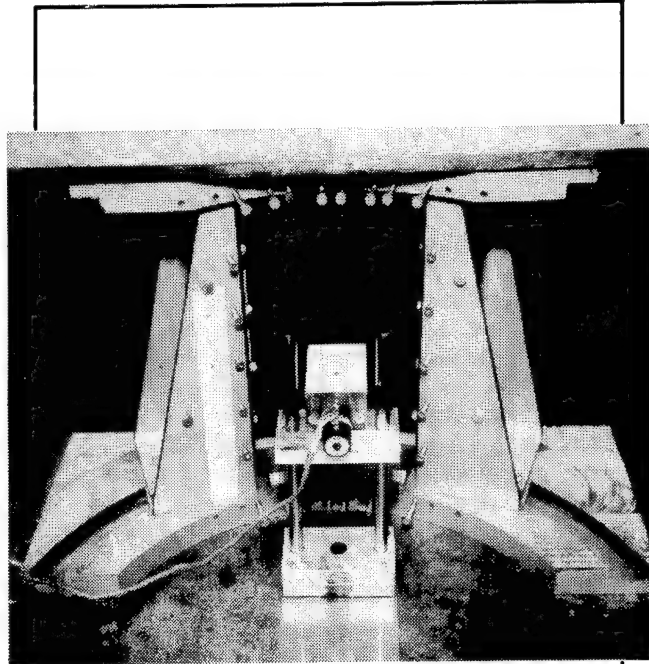


Figure 21 Rear View of
Buckling Setup

SMD7056

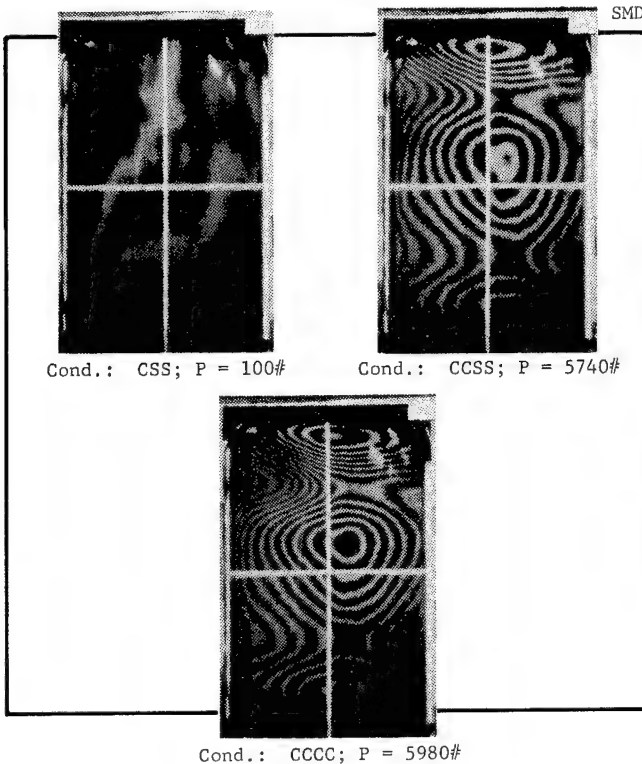


Figure 22 Moire Patterns
for -19E

SMD7057

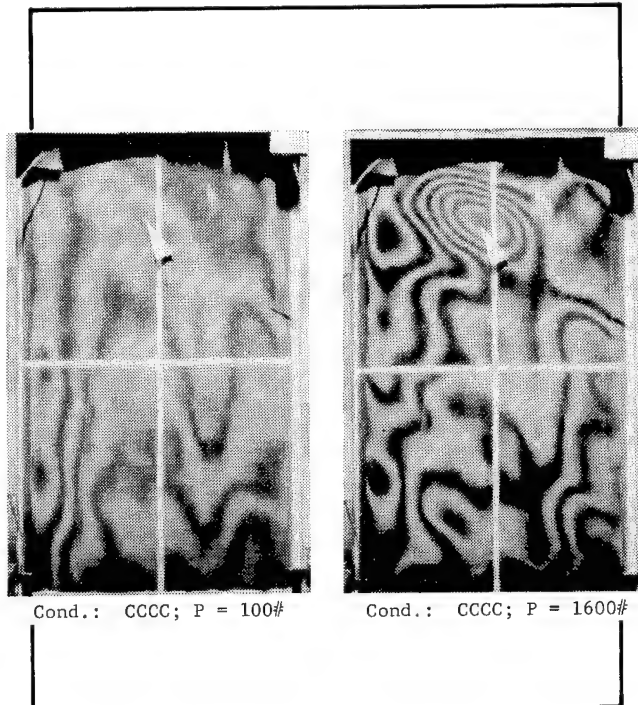


Figure 23 Moire Patterns
for -23C

SMD7058

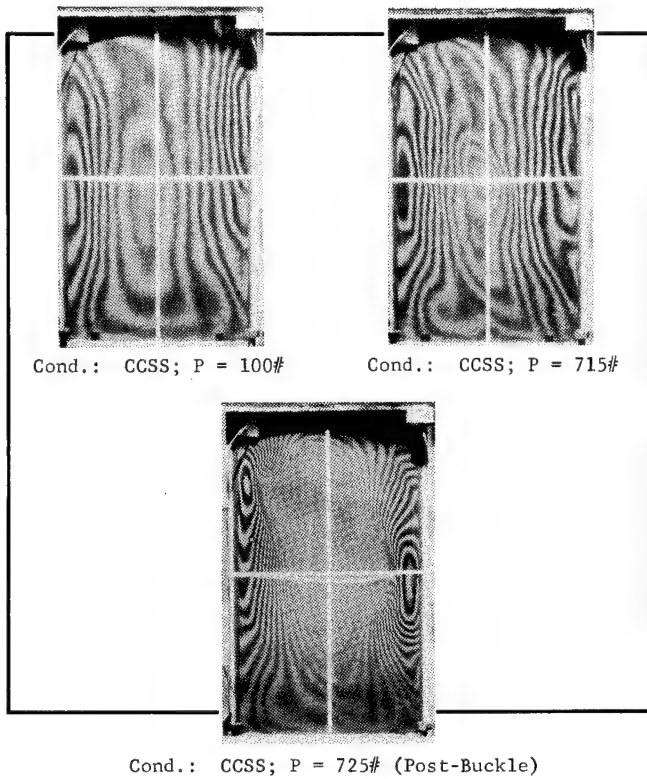


Figure 24 Moire Patterns
for -37A

SMD7059

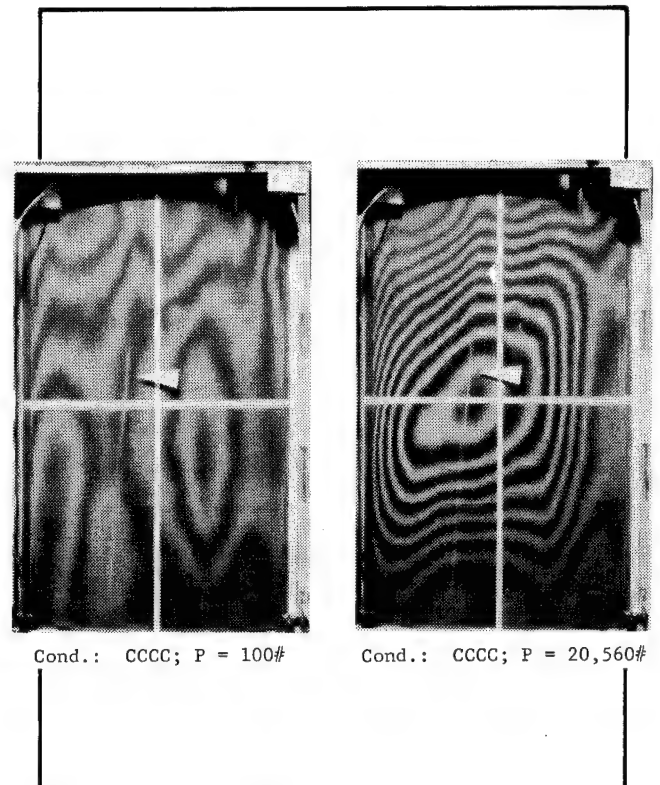


Figure 25 Moire Patterns
for -47B

SMD7060

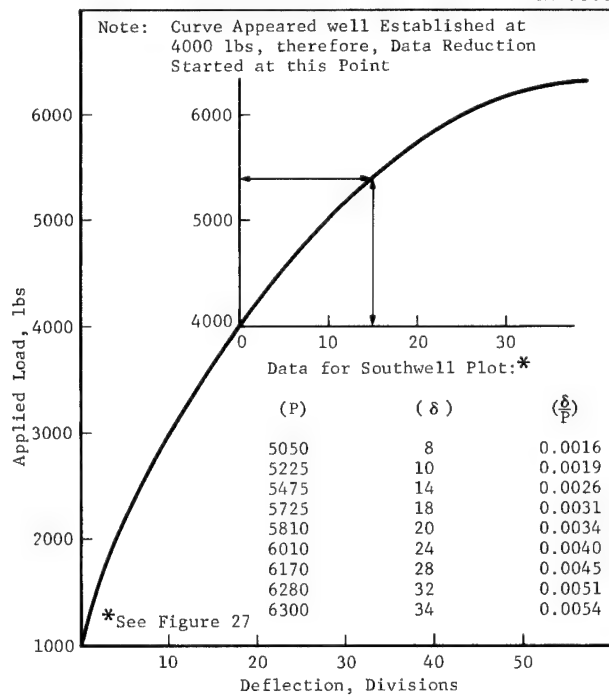


Figure 26 Typical Load-Deflection
Curve

SMD7061

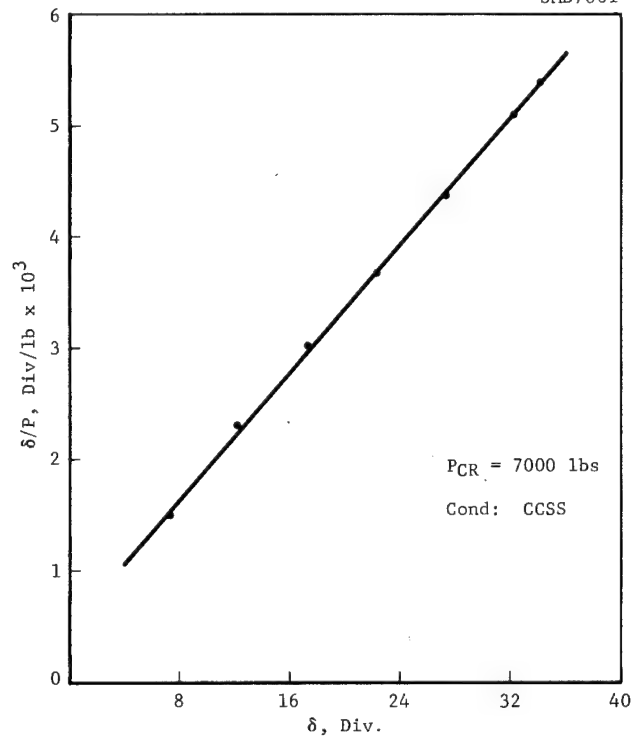


Figure 27 Southwell Curve
for -33B

analyzed. It has been used for the buckling of columns, beam-columns, plates, and more recently, shells.

The theoretical basis for the use of the Southwell method for shells may be found in the works of Tenerelli and Horton [10] and Galletly and Reynolds [11]. A modification of the method of Tenerelli and Horton was used here.

Briefly, the moire grid-shadow method was used in the initial load cycle (below the buckling load) to find the point of maximum deflection on the shell. The linear variable differential transformer (LVDT) was then positioned to read deflections at that point. On subsequent load cycles, the load-deflection plot for that point was read out on the rotating drum of the test machine. A typical plot is shown in Figure 26.

The actual Southwell plots were generated by using a Hewlett-Packard 9100B calculator with a plotter. A program was written to take the load-deflection data as input and produce a plot of (deflection/applied load) versus deflection. Using the straight portion of this plot, the buckling load is calculated as the inverse of the slope of the line.

The moire procedure used in obtaining buckling loads of the various panels proved to be quite satisfactory and saved the majority of panels for future tests. There were, however, a number of panels that snapped into a post-yield buckle before loading could be stopped. When this condition occurred the panels were damaged to the extent that subsequent load cycles produced lower buckling loads. On the other hand, when the loads were dumped at initial evidence of buckling, subsequent loading cycles produced repeatable results. On a few panels, all three methods (moire, Southwell and snap-through) were used to obtain the critical buckling load. Comparing the results of these methods, using Table V, it can be seen that satisfactory correlation exists.

Curved aluminum panels were also tested to obtain base reference data for evaluating the edge restraints of the fixture. The results from these tests indicated that the clamping action on the loaded edges of the specimens was very near the classical value, however, the simple supports provided slightly more than classical restraint. This excess edge moment was 10 inch-pounds per radian per inch of length. This value was determined to be within acceptable limits and the tests proceeded without further alterations in set-up procedures.

TABLE V
BUCKLING RESULTS FOR GRAPHITE EPOXY COMPOSITE CURVED PANELS

| PANEL NUMBER | LAMINATE IDENTI- FICATION | MEAN THICKNESS INCHES | THICKNESS MEAN DEVIATION INCHES | VERTICAL EDGES SIMPLY SUPPORTED, CURVED EDGES CLAMPED | | | | | | ALL EDGES CLAMPED | | | |
|-----------------|---------------------------------|-----------------------------|--|--|------------------------|---------------------------|---------------------|---------------------|-----|----------------------|------------------------|---------------------------|------|
| | | | | SNAP LOAD LBS. | MOIRE' LOAD LBS. | SOUTHWELL LOAD LBS. | SS8 LOAD LBS. | KNOCKDOWN FACTOR | | SNAP LOAD LBS. | MOIRE' LOAD LBS. | SOUTHWELL LOAD LBS. | |
| | | | | | | | | EXP | SS8 | | | | |
| 17A | [0/90]2s | 0.0592 | 0.0021 | | 6680 | 7323 | 7200 | .93 | .80 | | | | 7088 |
| 17B | [0/90]2s | 0.0528 | 0.0036 | | 4865 | | 5900 | .83 | .73 | | | | |
| 19A | [+45]2s | 0.0696 | 0.0030 | | 8660 | 8750 | 12400 | .70 | | | | | |
| 19B | [+45]2s | 0.0707 | 0.0030 | 9000 | | 9050 | 12700 | .71 | .61 | | | | |
| 19C | [+45]2s | 0.0713 | 0.0025 | | 8820 | | 13000 | .68 | .62 | | | | |
| 19D | [+45]2s | 0.0719 | 0.0019 | | 8760 | | 13200 | .66 | .59 | | | | |
| 19E | [+45]2s | 0.0598 | 0.0026 | | 5740 | | 9500 | .60 | .44 | | | 5980 | |
| 21A | [0/90]s | 0.0289 | 0.0015 | | 985 | 1125 | 1530 | .64 | .84 | | 1195 | 1175 | |
| 21B | [0/90]s | 0.0282 | 0.0013 | | 925 | | 1470 | .63 | .83 | | | | |
| 23A | [+45]s | 0.0354 | 0.0025 | 1870 | 1870 | 1914 | 4000 | .47 | | | | | |
| 23B | [+45]s | 0.0362 | 0.0033 | 1610 | | 1695 | 4180 | .38 | .35 | | | | |
| 23C | [+45]s | 0.0340 | 0.0018 | | 1590 | 1624 | 3780 | .42 | .35 | | | 1625 | |
| 23D | [+45]s | 0.0359 | 0.0025 | 1850 | | | 4130 | .45 | .47 | | | | |
| 23E | [+45]s | 0.0307 | 0.0013 | | 1280 | 1314 | 2950 | .43 | .46 | | | | |

TABLE V, Cont'd.

BUCKLING RESULTS FOR GRAPHITE-EPOXY COMPOSITE CURVED PANELS

| PANEL NUMBER | LAMINATE IDENTI- FICATION | MEAN THICKNESS INCHES | THICKNESS MEAN DEVIATION INCHES | VERTICAL EDGES SIMPLY SUPPORTED, CURVED EDGES CLAMPED | | | | | | ALL EDGES CLAMPED | | |
|-----------------|----------------------------------|-----------------------------|--|--|------------------------|---------------------------|---------------------|---------------------|-----|----------------------|------------------------|---------------------------|
| | | | | SNAP LOAD LBS. | MOIRE' LOAD LBS. | SOUTHWELL LOAD LBS. | SS8 LOAD LBS. | KNOCKDOWN FACTOR | | SNAP LOAD LBS. | MOIRE' LOAD LBS. | SOUTHWELL LOAD LBS. |
| | | | | | | | | EXP | SS8 | | | |
| 27 | (Alum) | 0.0630 | | 17000 | | | 23500 | .72 | .48 | | | |
| 29C | [⁺ 45] _{3s} | 0.1045 | 0.0027 | | 17760 | 23125 | 27700 | .64 | .63 | | | |
| 29D | [⁺ 45] _{3s} | 0.1066 | 0.0037 | | | 21889 | 29200 | .62 | .62 | | | |
| 29E | [⁺ 45] _{3s} | 0.0892 | 0.0040 | | 10780 | | 19700 | .55 | .52 | | | |
| 31A | [⁺ 45] _{2s} | 0.0343 | 0.0024 | 1550 | 1550 | 1759 | 2800 | .55 | .16 | | | |
| 31B | [⁺ 45] _{2s} | 0.0356 | 0.0038 | | 1505 | 1704 | 2900 | .52 | | | 1480 | |
| 31C | [⁺ 45] _{2s} | 0.0353 | 0.0017 | | 1520 | | 2900 | .52 | | | | |
| 31D | [⁺ 45] _{2s} | 0.0347 | 0.0021 | 1500 | | | 2800 | .54 | | | | |
| 31E | [⁺ 45] _{2s} | 0.0289 | 0.0015 | 975 | | | 2000 | .49 | .33 | | | |
| 33A | [⁺ 45] _{4s} | 0.0692 | 0.0031 | 7050 | | | 11700 | .60 | | | | |
| 33B | [⁺ 45] _{4s} | 0.0679 | 0.0024 | 6340 | 6300 | 7000 | 11300 | .56 | .50 | | | |
| 33C | [⁺ 45] _{4s} | 0.0622 | 0.0030 | | 5700 | 5750 | 9300 | .61 | .24 | | | |
| 33D | [⁺ 45] _{4s} | 0.0709 | 0.0035 | | 6620 | | 12200 | .54 | .29 | | | |
| 33E | [⁺ 45] _{4s} | 0.0591 | 0.0024 | 4000 | 4000 | 4021 | 8300 | .47 | | | | |

TABLE V, Cont'd.
BUCKLING RESULTS FOR GRAPHITE-EPOXY COMPOSITE CURVED PANELS

| PANEL NUMBER | LAMINATE IDENTI- FICATION | MEAN THICKNESS INCHES | THICKNESS MEAN DEVIATION INCHES | VERTICAL EDGES SIMPLY SUPPORTED, CURVED EDGES CLAMPED | | | | | ALL EDGES CLAMPED | | |
|-----------------|---------------------------------|-----------------------------|--|--|------------------------|---------------------------|---------------------|---------------------|----------------------|------------------------|---------------------------|
| | | | | SNAP LOAD LBS. | MOIRE' LOAD LBS. | SOUTHWELL LOAD LBS. | SS8 LOAD LBS. | KNOCKDOWN FACTOR | SNAP LOAD LBS. | MOIRE' LOAD LBS. | SOUTHWELL LOAD LBS. |
| | | | | | | | | | | | |
| 35A | [+45] _{6s} | 0.0902 | 0.0049 | | 9180 | 10270 | 20000 | .46 | .36 | | |
| 37A | [-30] _{2s} | 0.0282 | 0.0071 | 725 | 715 | | 2200 | .33 | .41 | | |
| 39A | [-30] _{4s} | 0.0580 | 0.0022 | | 4730 | | 8000 | .59 | .73 | 4985 | |
| 41A | [-30] _{6s} | 0.0900 | 0.0018 | | 10460 | 10435 | 17800 | .59 | .84 | | |
| 43A | [0] _{2s} | 0.0364 | 0.0020 | | 1315 | 1575 | 2100 | .63 | .68 | | |
| 43C | [0] _{2s} | 0.0368 | 0.0032 | 1540 | | | 2100 | .73 | .64 | | |
| 43D | [0] _{2s} | 0.0362 | 0.0024 | 1315 | 1290 | 1418 | 2100 | .63 | .64 | | |
| 43E | [0] _{2s} | 0.0294 | 0.0020 | 945 | | | 1800 | .53 | .49 | | |
| 45A | [0] _{4s} | 0.0701 | 0.0018 | | 5580 | 6468 | 8700 | .64 | .67 | 7300 | 7704 |
| 45B | [0] _{4s} | 0.0699 | 0.0028 | 5735 | | | 8700 | .66 | .62 | | |
| 45C | [0] _{4s} | 0.0696 | 0.0014 | | 5300 | 5553 | 8700 | .56 | .66 | | |
| 45D | [0] _{4s} | 0.0695 | 0.0014 | | 5080 | 5610 | 8700 | .58 | .66 | 6600 | 7123 |
| 45E | [0] _{4s} | 0.0582 | 0.0029 | | 5105 | 5122 | 5800 | .88 | .64 | | |
| 47A | [0] _{6s} | 0.1064 | 0.0030 | | 16500 | 18362 | 21600 | .76 | .61 | | |

TABLE V, Cont'd.

BUCKLING RESULTS FOR GRAPHITE-EPOXY COMPOSITE CURVED PANELS

| PANEL NUMBER | LAMINATE IDENTI- FICATION | MEAN THICKNESS INCHES | THICKNESS MEAN DEVIATION INCHES | VERTICAL EDGES SIMPLY SUPPORTED, CURVED EDGES CLAMPED | | | | | | ALL EDGES CLAMPED | | | |
|-----------------|---------------------------------|-----------------------------|--|--|------------------------|---------------------------|---------------------|---------------------|-----|----------------------|------------------------|---------------------------|--|
| | | | | SNAP LOAD LBS. | MOIRE' LOAD LBS. | SOUTHWELL LOAD LBS. | SS8 LOAD LBS. | KNOCKDOWN FACTOR | | SNAP LOAD LBS. | MOIRE' LOAD LBS. | SOUTHWELL LOAD LBS. | |
| | | | | | | | | EXP | SS8 | | | | |
| 47B | [0]6s | 0.1039 | 0.0027 | | 18000 | 19598 | 20600 | .85 | .62 | | 20560 | 21538 | |
| 47C | [0]6s | 0.1013 | 0.0035 | | 16760 | 17812 | 19600 | .56 | .59 | | | | |
| 49A | [0/90]3s | 0.0880 | 0.0026 | | 14680 | 16625 | 16200 | .91 | .79 | | | | |
| 49B | [0/90]3s | 0.0781 | 0.0034 | | 12460 | 14118 | 12500 | .99 | .79 | | | | |
| 51A | [+30]s | 0.0296 | 0.0019 | | 1150 | | 2630 | .44 | .55 | | | | |
| 53A | [+30]2s | 0.0557 | 0.0023 | | 5405 | 5818 | 7750 | .70 | .70 | | | | |
| 55A | [+30]3s | 0.0807 | 0.0026 | | 12900 | 13860 | 17000 | .76 | .68 | | | | |

TABLE V, Cont'd.

BUCKLING RESULTS FOR GRAPHITE-EPOXY COMPOSITE CURVED PANELS

| PANEL NUMBER | LAMINATE IDENTIFICATION | MEAN THICKNESS INCHES | THICKNESS MEAN DEVIATION INCHES | VERTICAL EDGES SIMPLY SUP- PORTED CURVED EDGES CLAMPED | | | | ALL EDGES CLAMPED | | | |
|-----------------|-----------------------------|-----------------------------|--|---|------------------------|---------------------------|---------------------|----------------------------|----------------------|------------------------|---------------------------|
| | | | | SNAP LOAD LBS. | MOIRE' LOAD LBS. | SOUTHWELL LOAD LBS. | SS8 LOAD LBS. | KNOCKDOWN FACTOR EXP | SNAP LOAD LBS. | MOIRE' LOAD LBS. | SOUTHWELL LOAD LBS. |
| 57A | [0/-45/90/+45] _s | 0.0574 | 0.0018 | | 8240 | 8966 | 10000 | .82 | .90 | | |
| 57B | [0/-45/90/+45] _s | 0.0499 | 0.0028 | | 6640 | 6691 | 7500 | .86 | .80 | | |
| 57C | [0/-45/90/+45] _s | 0.0516 | 0.0023 | | 6460 | 6897 | 7900 | .82 | .85 | 7100 | |
| 57D | [0/-45/90/+45] _s | 0.0499 | 0.0028 | | 5820 | 6416 | 7500 | .78 | .80 | | |
| 57E | [0/-45/90/+45] _s | 0.0524 | 0.0032 | | 6960 | 7194 | 8250 | .84 | .78 | | |
| 59A | [0/±60] _s | 0.0422 | 0.0010 | | 3355 | 3595 | 5200 | .64 | .92 | 3730 | 3846 |
| 59B | [0/±60] _s | 0.0392 | 0.0018 | | 3390 | 3626 | 4450 | .76 | .84 | 3685 | 3530 |
| 59C | [0/±60] _s | 0.0382 | 0.0026 | | 3400 | 3582 | 4200 | .81 | .79 | | |
| 59D | [0/±60] _s | 0.0397 | 0.0020 | | 3000 | 3170 | 4600 | .65 | .82 | | |
| 59E | [0/±60] _s | 0.0390 | 0.0028 | | 3460 | 3846 | 4420 | .78 | .76 | | |
| 61A | [0/±60] _{2s} | 0.0870 | 0.0026 | | 22950 | 23871 | 27400 | .84 | .76 | | |
| 61B | [0/±60] _{2s} | 0.0794 | 0.0041 | | 18080 | 18571 | 22800 | .79 | .70 | | |
| 61C | [0/±60] _{2s} | 0.0785 | 0.0034 | | 16920 | 18136 | 22300 | .76 | .71 | | |

TABLE V, Concluded
BUCKLING RESULTS FOR GRAPHITE-EPOXY COMPOSITE CURVED PANELS

| PANEL NUMBER | LAMINATE IDENTIFICATION | MEAN THICKNESS INCHES | THICKNESS MEAN DEVIATION INCHES | VERTICAL EDGES SIMPLY SUP- PORTED CURVED EDGES CLAMPED | | | ALL EDGES CLAMPED | | |
|-----------------|----------------------------|-----------------------------|--|---|---------------------------|---------------------|-------------------------------|---------------------------|--|
| | | | | SNAP MOIRE LOAD LBS. | SOUTHWELL LOAD LBS. | SS8 LOAD LBS. | SNAP MOIRE LOAD LBS. | SOUTHWELL LOAD LBS. | |
| | | | | | | | | | |
| 61D | [0/±60]₂s | 0.0782 | 0.0029 | 18800 | 19000 | 22300 | .84 | .74 | |
| 67 | Alum | 0.0320 | | 3825 | | 8500 | .45 | | |
| 69A | [0₂/±45]ₛ | 0.0512 | 0.0026 | 5500 | 5663 | 8150 | .68 | .63 | |
| 69B | [0₂/±45]ₛ | 0.0521 | 0.0019 | 5410 | 5114 | 8150 | .62 | .70 | |
| 69C | [0₂/±45]ₛ | 0.0488 | 0.0028 | 5385 | 5604 | 7400 | .73 | .61 | |
| 69D | [0₂/±45]ₛ | 0.0504 | 0.0025 | 5310 | 5581 | 7900 | .67 | .63 | |
| 69E | [0₂/±45]ₛ | 0.0506 | 0.0034 | 5870 | 5882 | 8000 | .73 | .58 | |
| 71A | [0/±45]ₛ | 0.0408 | 0.0021 | 2930 | 3187 | 4870 | .60 | .75 | |
| 71B | [0/±45]ₛ | 0.0394 | 0.0019 | 2595 | 2803 | 4540 | .57 | .76 | |
| 71C | [0/±45]ₛ | 0.0394 | 0.0021 | 2810 | 2910 | 4540 | .62 | .75 | |
| 71D | [0/±45]ₛ | 0.0397 | 0.0020 | 2610 | 2942 | 4600 | .57 | .75 | |
| 71E | [0/±45]ₛ | 0.0390 | 0.0025 | 2310 | 3333 | 4440 | .70 | .71 | |

During the course of the buckling tests, a documentary film was generated showing the installation and testing of a typical graphite panel. This film, which is retained in the Composite Structures Engineering Group, provides a graphic display of the moire pattern development as the panel was loaded and the onset of buckling.

Table V includes the SS8 classical buckling load predictions for each panel as well as the knockdown factor predicted by SS8 based on the standard deviation in thickness of each panel. For the aluminum panels, the knockdown factor is found from the equation (Reference [50])

$$\gamma = 1 - 0.901(1 - e^{-\frac{1}{2}\sqrt{R/t}}) \quad (112)$$

Although the knockdown factor based on the standard deviations of the panel thickness is not always conservative, it does indicate trends fairly well and should be investigated further.

Figure 28 is a summary of all the buckling data obtained in terms of the ratio between experimental and classical buckling load versus R/t . In Figures 29 through 38, the results according to laminate orientation are separated to show that some types of laminates seem to be much more sensitive to imperfections than others and that the thin laminates are the most sensitive.

3.2.2 Panel Shear Tests

Two test specimens, one graphite-epoxy and one boron-epoxy, were used in this investigation. Each specimen consisted of an assembly of four quarter-circle panels nine inches long on a 12-inch radius, as shown in Figure 39. In both cases the basic test panels consisted of eight plies oriented at ± 45 degrees to the cylinder axis.

Loads were applied to the test apparatus to produce pure torsion. Strain gages were installed on both the inner and outer surfaces of each panel. Electrical deflection gages were installed inside the specimens to record radial deflection of the panels.

Testing was directed toward (1) the determination of the buckling stress and (2) the examination of the post-buckling strength. Determination of buckling stresses required loading the specimens to 75-90 percent of the buckling load. This

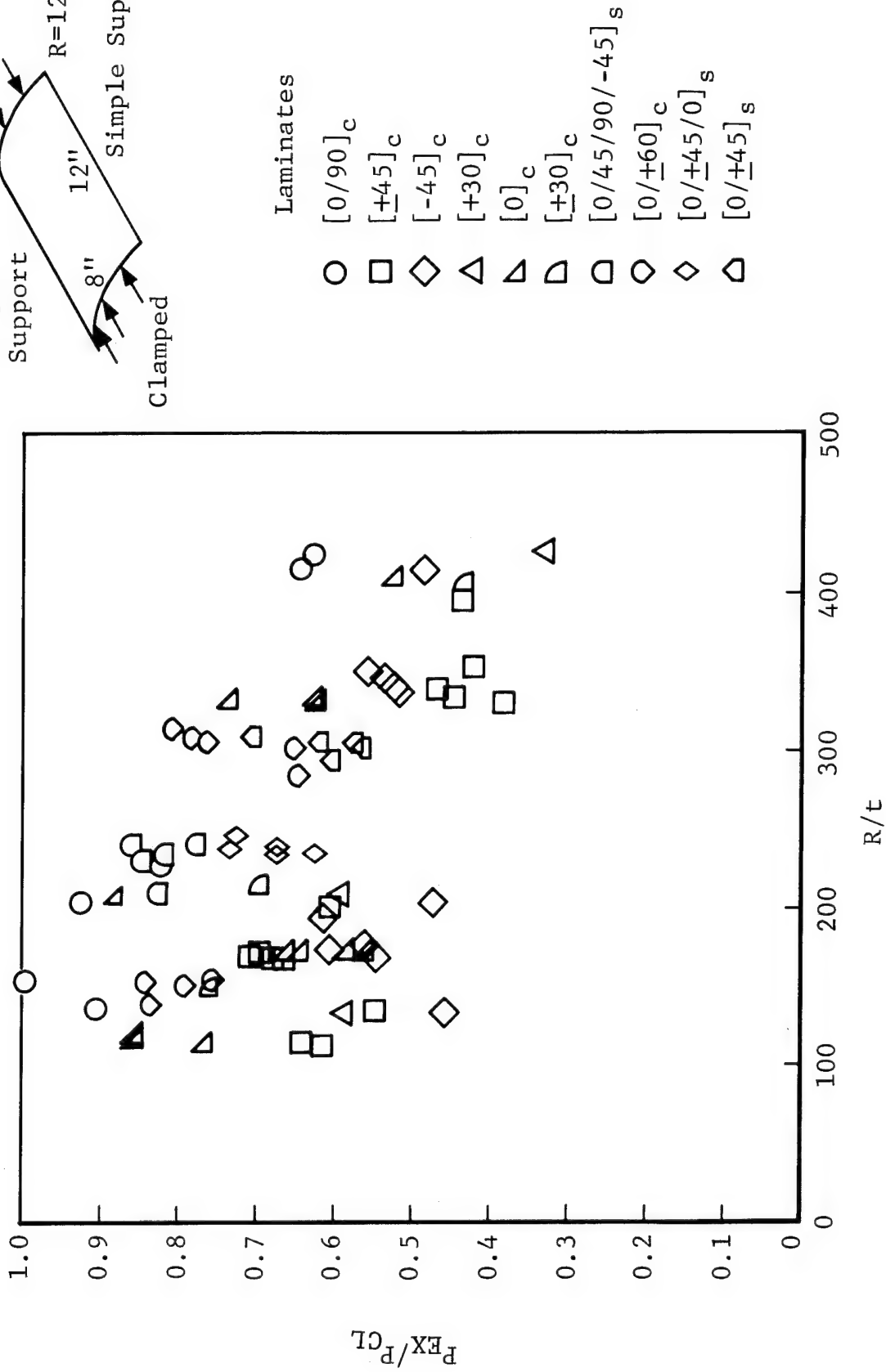
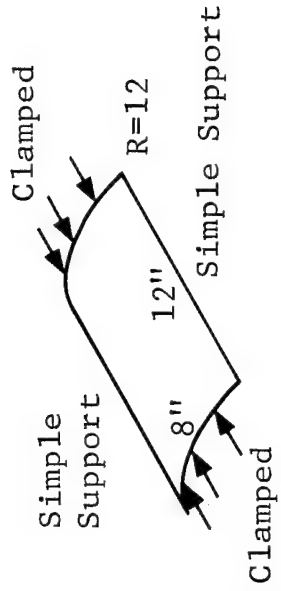


Figure 28 Curved Panel Buckling Summary

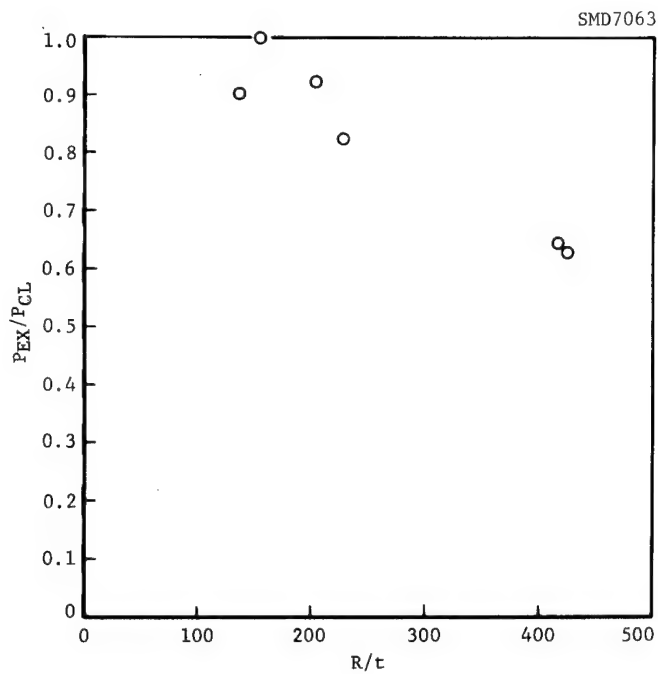


Figure 29 Curved Panel Buckling
Plot: $[0/90]_c$

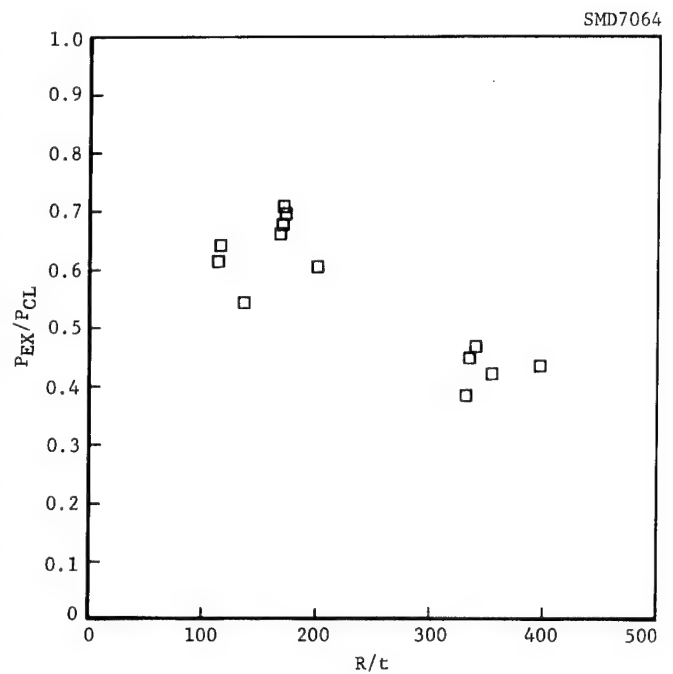


Figure 30 Curved Panel Buckling
Plot: $[+45]_c$

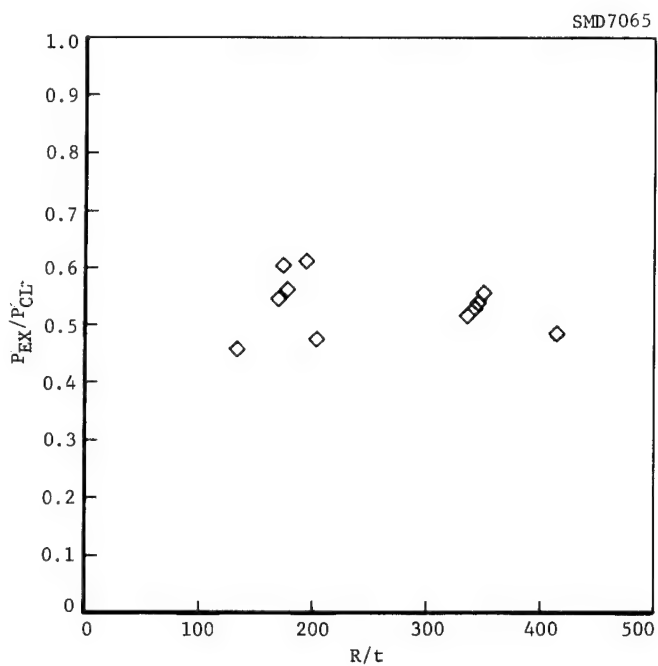


Figure 31 Curved Panel Buckling
Plot: $[-45]_c$

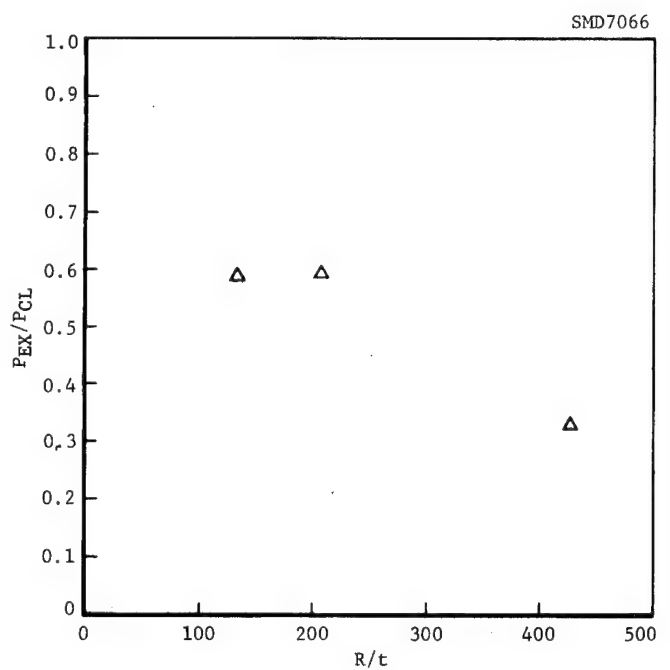


Figure 32 Curved Panel Buckling
Plot: $[+30]_c$

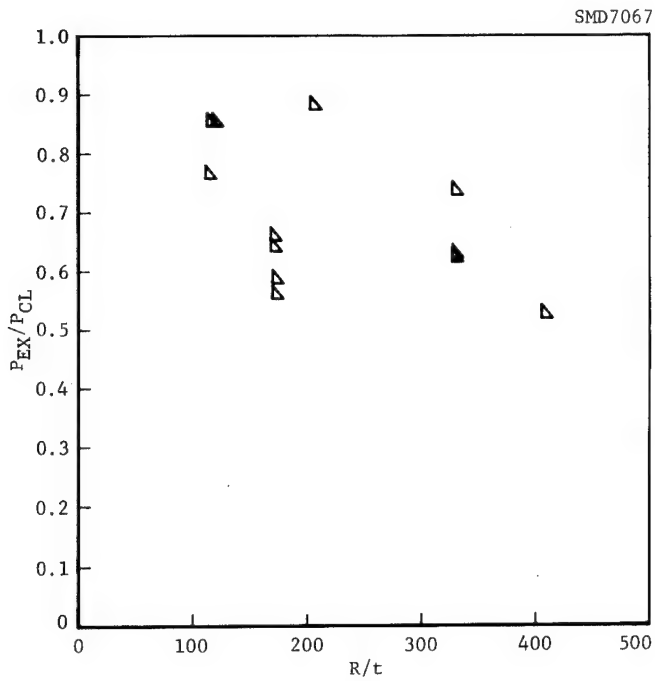


Figure 33 Curved Panel Buckling
Plot: $[0]_c$

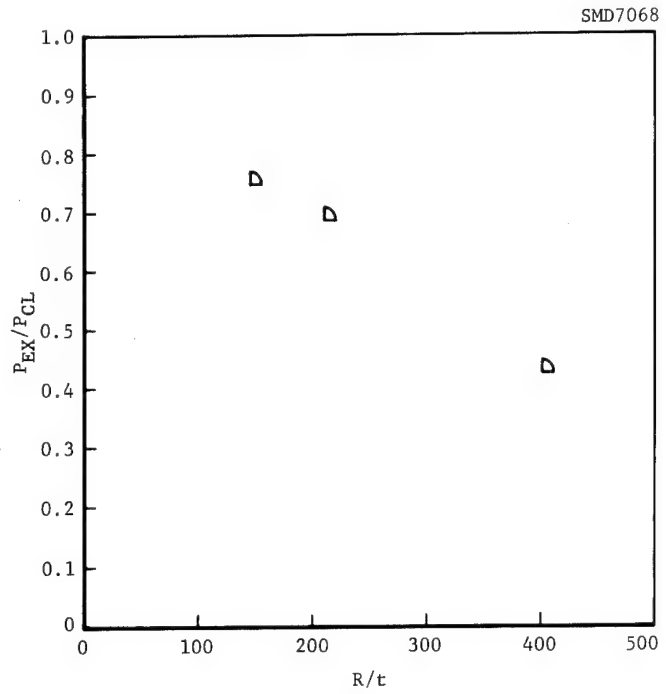


Figure 34 Curved Panel Buckling
Plot: $[\pm 30]_c$

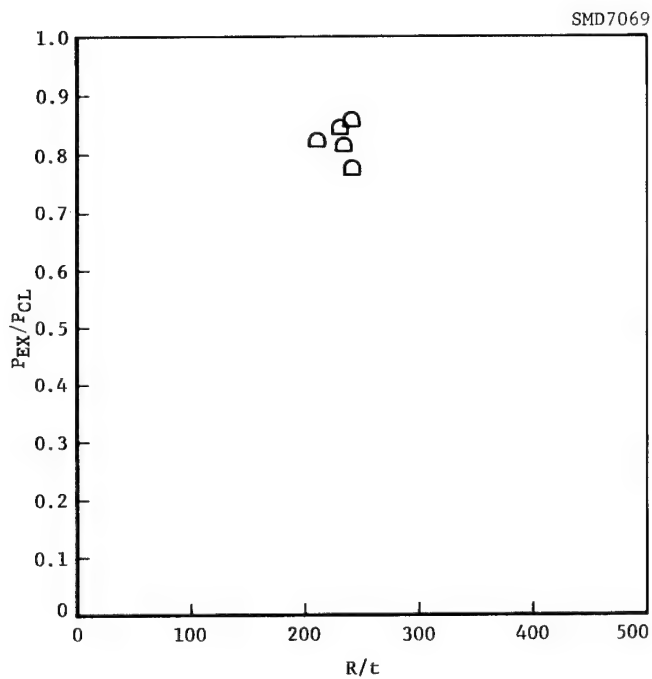


Figure 35 Curved Panel Buckling
Plot: $[0/45/90/-45]_s$

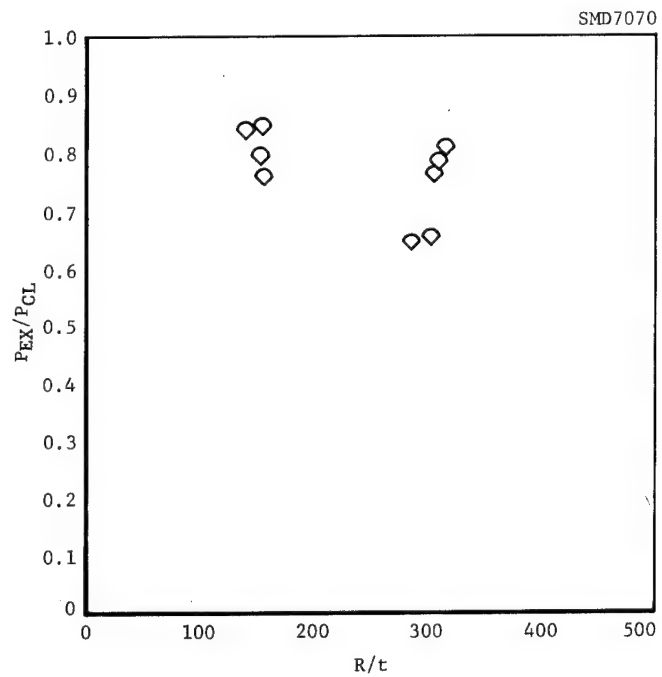


Figure 36 Curved Panel Buckling
Plot: $[0/\pm 60]_c$

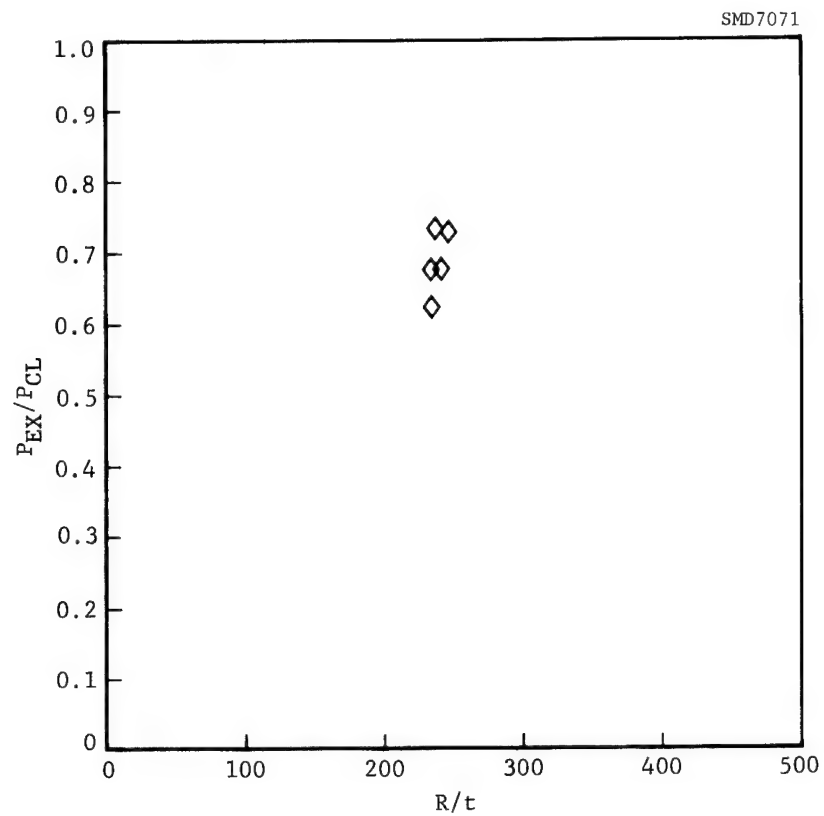


Figure 37 Curved Panel Buckling Plot: $[0/\pm 45/0]_s$

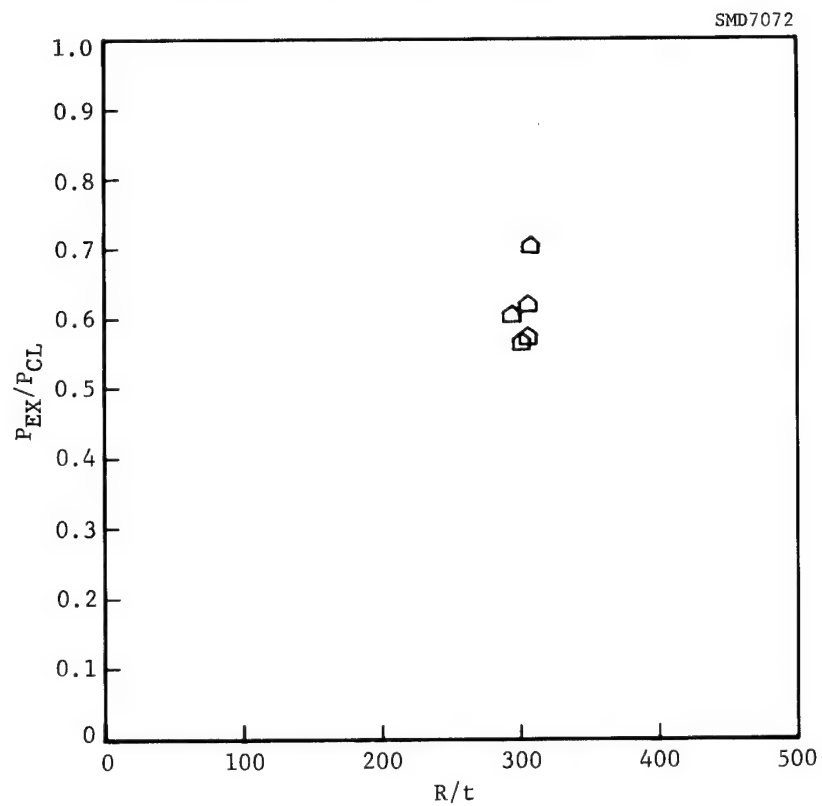


Figure 38 Curved Panel Buckling Plot: $[0/\pm 45]_s$

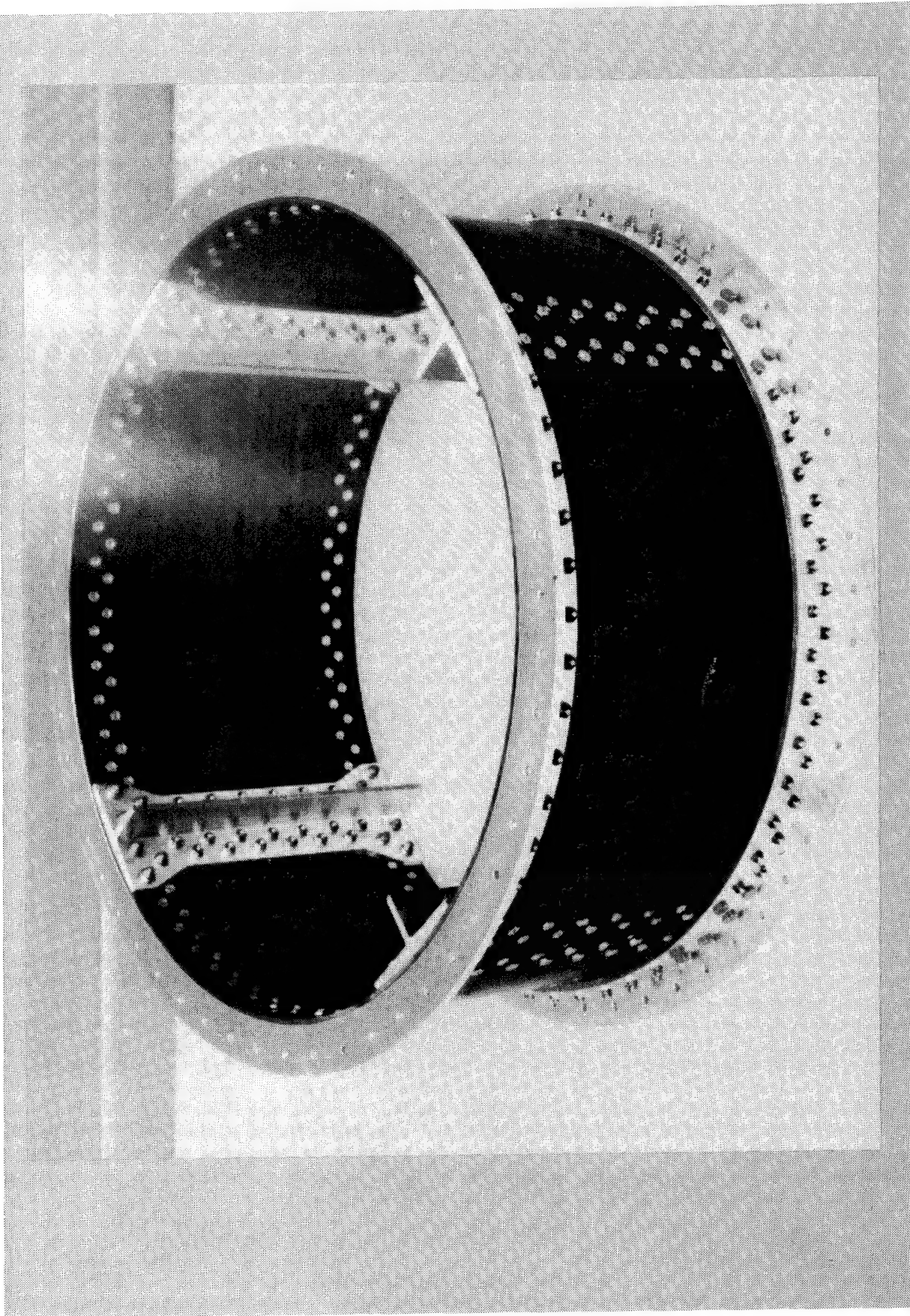


Figure 39 Curved Panel Test Assembly

procedure was usually repeated several times to check the repeatability of the data. This process was repeated for both directions of applied torque to determine the buckling stresses for different directions of applied shear. Because the composite panels consist of relatively few plies, stacking results in a basic imbalance with respect to laminate bending. This results in significantly different values of shear buckling stress of the panel for opposite directions of shear application.

Buckling stresses were experimentally determined through a "modified" Southwell Method which is a logical extension of the works of Galletly and Reynolds [11], and of Horton and Craig [12]. This method requires loading only near the actual buckling load which is desirable since actually buckling the test specimen could cause local damage and affect subsequent results. Moreover, the method allows use of the more reliable strain gages as opposed to deflection gages.

This method utilizes the stress (or load) versus surface strain curve from any point on the buckle at loads approaching buckling. This curve becomes increasingly nonlinear as the buckling load is approached, because of the increase of local bending at the buckle. The departure from linearity in terms of strain is defined as $\Delta\epsilon$. According to Galletly and Reynolds [11], the buckling stress (load) is equal to the inverse slope of the $\Delta\epsilon/P$ versus $\Delta\epsilon$ curve, (P may denote either load or stress). This technique was applied to all strain data taken during these tests with generally good results. Values of ϵ much below 100 $\mu\text{in./in.}$ generally give unreliable results because of the sensitivity limits on instrumentation. Typical results are shown below in the separate discussions of each test.

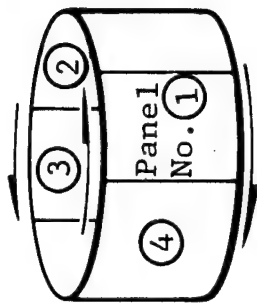
Results of the buckling tests on the graphite-epoxy panels are summarized in Table VI. Data was obtained from each of the four panels composing the test assembly. Conditions 1 and 2 refer to different directions of shear. As is seen, a significant difference in buckling loads results.

Strain gage rosettes placed back-to-back in pairs were used to obtain the data for the buckling stress determination. These gages were also used to compute K_{xy} which relates the shear stress on each panel τ to the total load P applied to the test assembly. These gages, with the exception of 1 and 2 (Table VI) are located at the center of the panel. Gages 1 and 2 were located in a corner near the edge.

Table VI GRAPHITE-EPOXY-CURVED PANEL SHEAR
BUCKLING RESULTS

8 Ply $\pm 45^\circ$ Laminate

Average
Thickness = .056 in.



| | | Condition 1 $\tau_{xy} > 0$ | | | Condition 2 $\tau_{xy} < 0$ | | | |
|-----------|----------|--|------------------|----------------------|--|------------------|----------------------|---|
| | | Southwell | | | Southwell | | | |
| Panel No. | Position | K_{xy} (psi/lb) | P_{CR} (lb) | τ_{CR} (psi) | K_{xy} psi/lb | P_{CR} (lb) | τ_{CR} (psi) | Deflection P_{CR} (lb) τ_{CR} (psi) |
| 1 | 1 | .445 | - | - | .475 | 27,325 | 12,960 | - |
| 1 | 2 | .445 | - | - | .475 | - | - | - |
| 1 | 3 | .445 | 18,431 | 8210 | .475 | 26,667 | 12,670 | 26,000 12,350 |
| 1 | 4 | .445 | 18,434 | 8210 | .475 | 26,730 | 12,710 | - |
| 2 | 5 | .476 | - | - | .475 | 26,774 | 12,720 | 27,000 12,800 |
| 2 | 6 | .476 | - | - | .475 | 26,570 | 12,610 | - |
| 3 | 7 | .476 | 19,020 | 9060 | .481 | - | - | 26,500 12,750 |
| 3 | 8 | .476 | 18,400 | 8770 | .481 | - | - | - |
| 4 | 9 | .516 | 18,950 | 9780 | .508 | - | - | 24,000 12,200 |
| 4 | 10 | .516 | 18,730 | 9690 | .508 | - | - | - |
| | | Theory $\tau_{CR} = 9170$ psi CL-CL $\tau_{CR} = 7420$ psi SS-SS | | | Theory $\tau_{CR} = 13,670$ psi CL-CL $\tau_{CR} = 10,720$ psi SS-SS | | | |

Deflection gages were placed to monitor lateral deflection at the panel center. Because of their low sensitivity these gages did not record any appreciable deflection until the panels actually buckled and very large deflections resulted. This behavior is shown in Figure 40. The points at which the deflections became large are those values listed in Table VI. These values support the Southwell data very well.

Theoretical buckling stresses were determined for the case of clamped edges and simply supported edges. The values (Table VI) for the clamped edges agree very well with the experimental results. Actual edge conditions approach the clamped case because of the stiff edgemembers and ample mechanical fasteners used.

An example of typical data used in the Southwell determination is shown in Figure 41. This data was taken for Condition 1 at Panel 4. The associated Southwell plots are seen in Figure 42.

Post-buckling behavior of the graphite-epoxy panels was characterized by large deflections with several buckles visible in each panel (see Figure 43). The behavior in terms of deflection is illustrated in Figure 2. Buckling of each panel occurred in sequence with a load drop accompanying each. With all four panels buckled, only a small amount of additional load was carried (20%) before failure. Failure occurred catastrophically at an average panel stress of approximately 16,000 psi as typically shown in Figures 44 and 45.

Results of the boron-epoxy buckling tests are summarized in Table VII. As before, loads and buckling stresses for both directions of loading were obtained with back-to-back strain gages on each of the four panels.

The data is seen to be very consistent. Analysis is seen to agree favorably as before although the results approach the case of simply-supported edges.

Typical load-strain curves and the associated Southwell plot for the boron panels are shown in Figures 46 and 47.

Visual and photographic observations of the post buckling behavior revealed that cracks appeared very soon after buckling occurred. Very little additional load was carried beyond buckling. The highest load attained was 21,500 pounds while buckling occurred at 19,000 to 20,000 pounds.

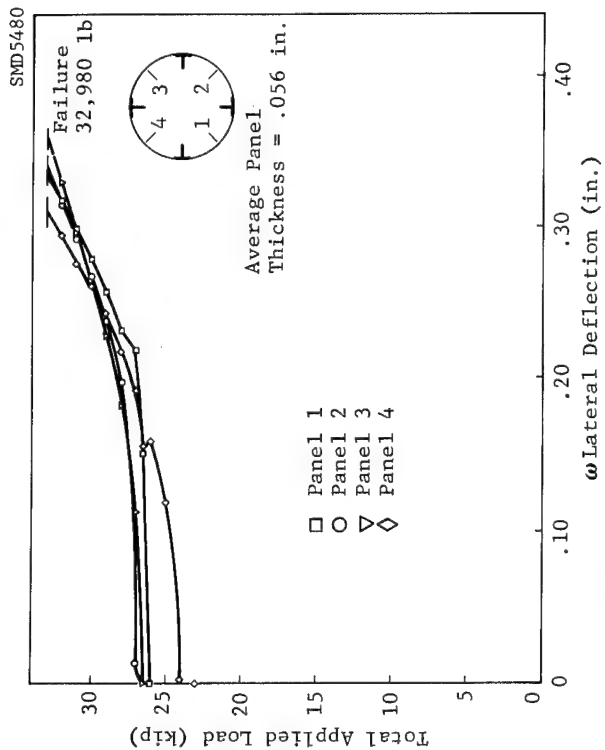


Figure 40 Load Versus Deflection for Graphite Shell

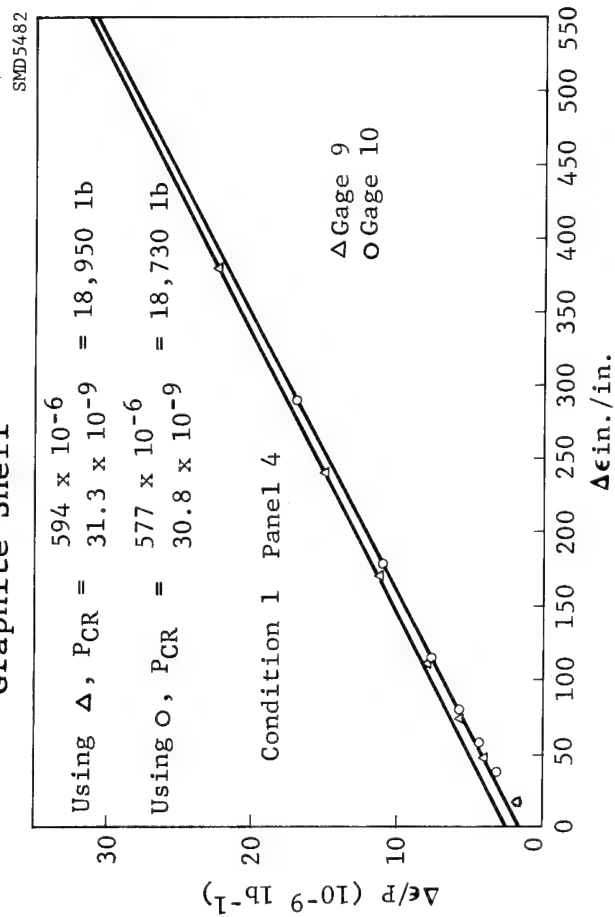


Figure 42 Southwell Plot - Graphite Curved Panel

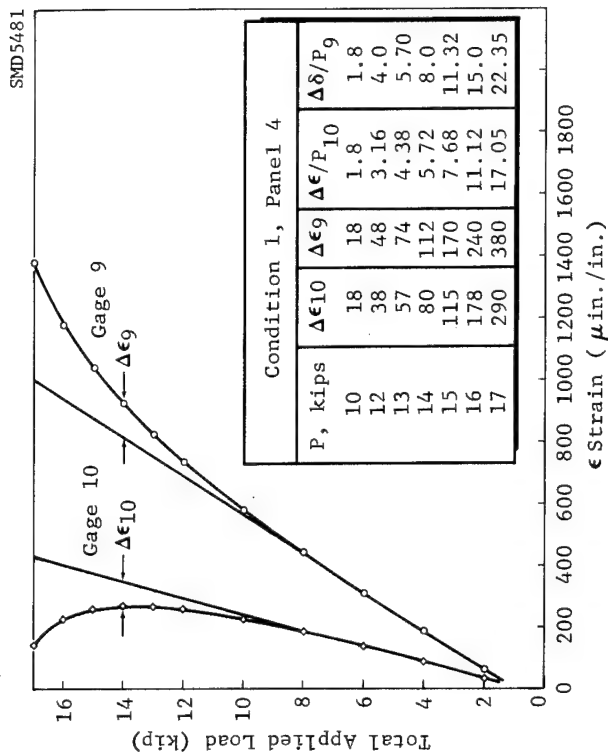


Figure 41 Load Versus Strain-Graphite Curved Panel Test

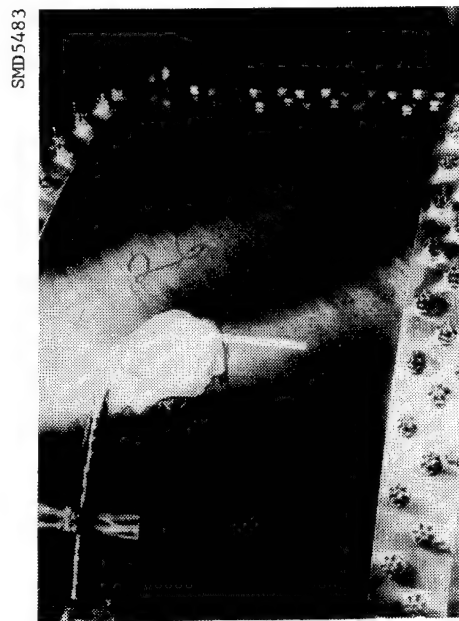


Figure 43 Graphite-Epoxy Curved Panel After Buckling

SMD 5484

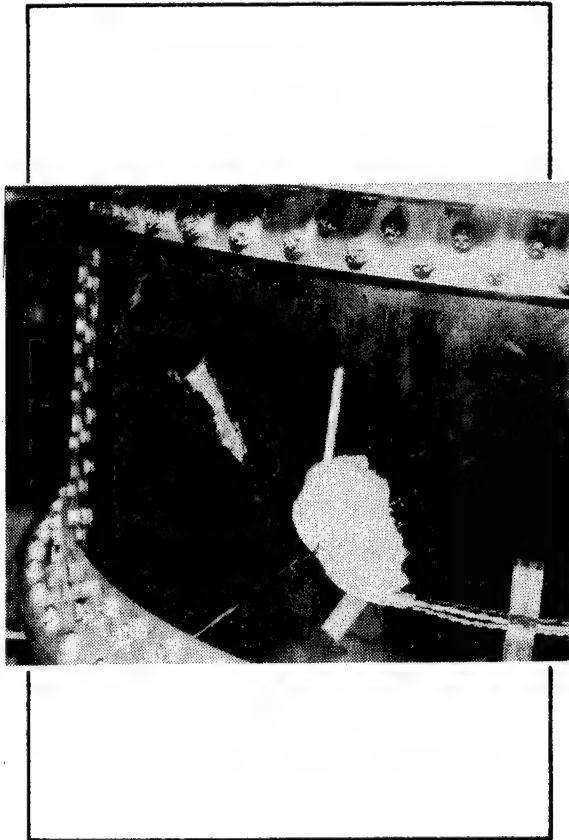


Figure 44 Failed Graphite-Epoxy Curved Panel

SMD 5485

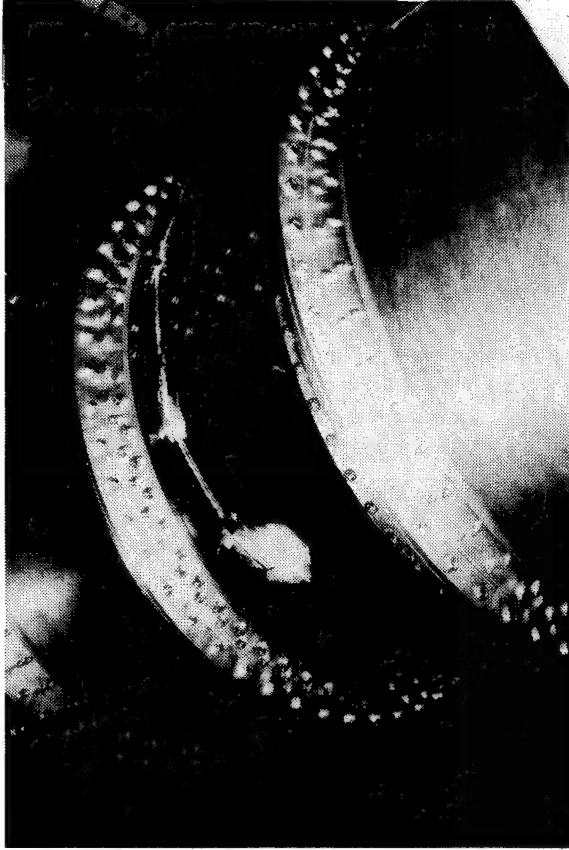


Figure 45 Failed Graphite-Epoxy Curved Panel - Overall View

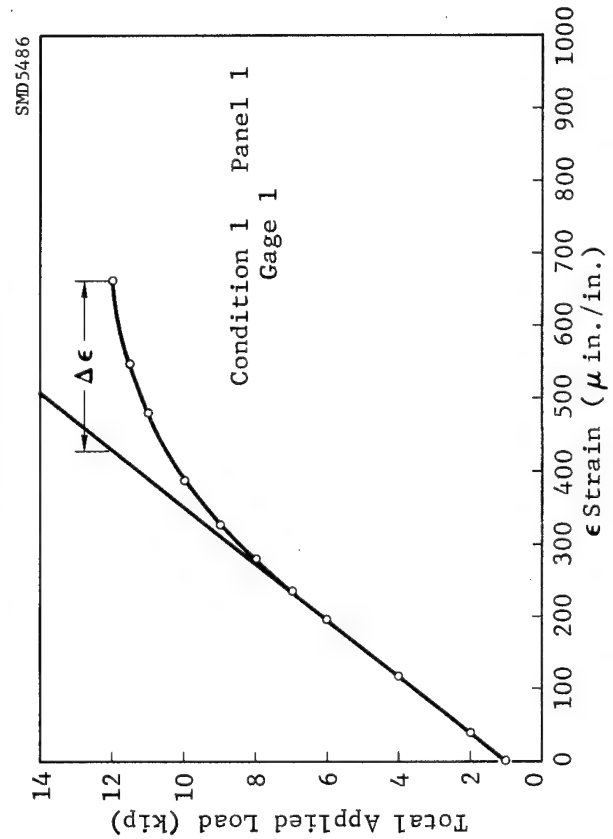


Figure 46 Load Versus Strain-Boron Curved Panel

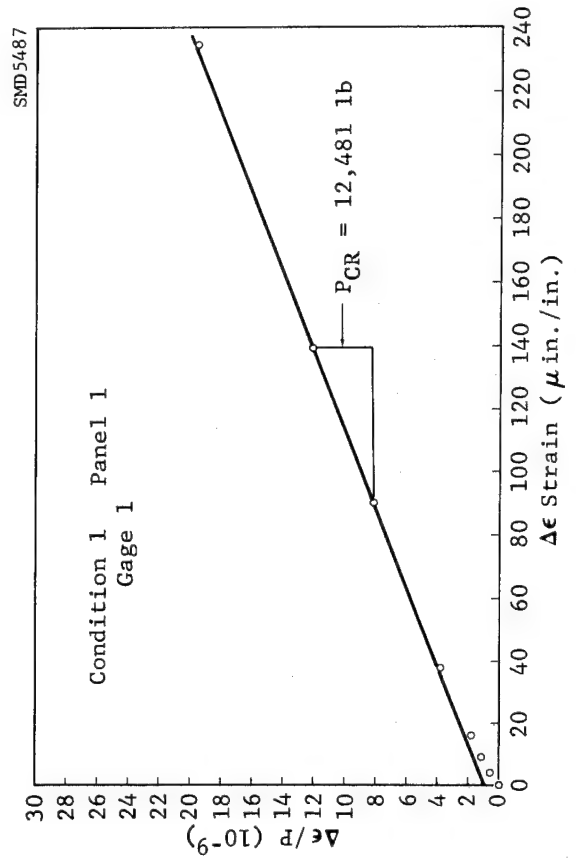
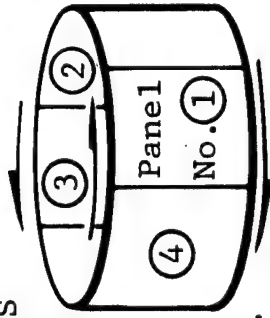


Figure 47 Southwell Plot - Boron Curved Panel

Table VII BORON-EPOXY CURVED PANEL SHEAR BUCKLING RESULTS



8 Ply $\pm 45^\circ$ Laminate
Average Thickness = .042 in.

| | | Condition 1 $\tau_{xy} > 0$ | | | Condition 2 $\tau_{xy} < 0$ | | | |
|-----------|----------|--|------------------|----------------------|--|------------------|----------------------|------------|
| Panel No. | Position | Southwell | | | K_{xy} psi/lb | Southwell | | |
| | | K_{xy} (psi/lb) | P_{CR} (lb) | τ_{CR} (psi) | | P_{CR} (lb) | τ_{CR} (psi) | Deflection |
| 1 | 1 | .613 | 12,481 | 7650 | .608 | 20,154 | 12,220 | 20,250 |
| 1 | 2 | .613 | 12,424 | 7620 | .608 | 19,468 | 11,820 | - |
| 2 | 3 | .603 | 13,742 | 8290 | .595 | 19,862 | 11,810 | 20,250 |
| 2 | 4 | .603 | 14,078 | 8470 | .595 | 19,665 | 11,700 | - |
| 3 | 5 | .598 | 13,864 | 8290 | .592 | 19,595 | 11,600 | 19,800 |
| 3 | 6 | .598 | 14,190 | 8480 | .592 | 19,091 | 11,300 | - |
| 4 | 7 | .594 | - | - | .592 | 19,855 | 11,750 | 20,700 |
| 4 | 8 | .594 | - | - | .592 | 19,760 | 11,710 | - |
| | | Theory | | | Theory | | | |
| | | $\tau_{CR} = 9140$ psi CL-CL $\tau_{CR} = 7600$ psi SS-SS | | | $\tau_{CR} = 13,290$ psi CL-CL $\tau_{CR} = 10,480$ psi SS-SS | | | |

3.3 VIBRATION

The vibration option was run extensively in checkout of SS8. Again, the anisotropic plate capability was checked with RA5 and showed good agreement.

The work of Sewall (Reference [14]) was used to compare natural frequency data for isotropic curved panels. As an example of the type of correlation obtained, the following results were obtained for an aluminum panel with $a = 11.0$ inches, $b = 9.0$ inches, $t = 0.028$ inch, and $R = 48.0$ inches. For one longitudinal and two circumferential modes, the following results were obtained:

| | <u>f, cps</u> |
|---|---------------|
| SS8, simply supported edges | 180.0 |
| Sewall analysis, simply supported edges | 184.0 |
| SS8, clamped edges | 468.6 |
| Sewall analysis, clamped edges | 536.5 |

The results indicate that SS8 gives a better frequency estimate than Sewall's analysis, since an energy solution gives an upper bound for the frequency, and SS8 shows a lower frequency in both cases. This is to be expected because Sewall neglected modal coupling effects in his one-term Rayleigh-type analysis.

For isotropic cylinders, the results of Park, et al. (Reference [15]), were used for comparison. They tested a steel cylinder built in at one end and free at the other. The dimensions were $a = 48.0$ inches, $R = 10.0$ inches, and $t = 0.03$ inches. They found the lowest natural frequency at $m = 1$, $n = 4$ of 50.4 cps. SS8 predicts a value of 51.9 cps. For $m = 1$, $n = 3$, the experimental value was 51.5 cps., while SS8 predicts 55.3 cps. For $m = 1$, $n = 5$, the experimental value was 70.9 cps., while SS8 predicts 71.5 cps.

The anisotropic capability of SS8 was tested by comparing its results with those of Bert, et al. (Reference [16]), who presented exact analytical solutions for the natural frequencies of anisotropic simply-supported cylinders. As an example, they studied a two-layer, cross-ply cylinder using material properties typical of boron-epoxy. Some examples of the excellent agreement obtained are shown below.

| <u>SS8</u> | <u>Ref. (11)</u> | <u>M</u> | <u>N</u> |
|------------|------------------|----------|----------|
| 235 cps | 235 cps | 1 | 2 |
| 254 cps | 253 cps | 1 | 3 |
| 443 cps | 443 cps | 2 | 3 |

The dynamics of a cylinder with four internal stringers has been investigated and these investigations are documented in References [17], [18], and [19]. The SS8 results for this case show its discrete stiffener capability.

| | <u>SS8 Anal.</u> | <u>Ref. 17 Expt.</u> | <u>Ref. 18 Anal.</u> | <u>Ref. 19 Anal.</u> |
|--------------|------------------|----------------------|----------------------|----------------------|
| M = 1, N = 3 | 163 cps | | 158 cps | 159 cps |
| M = 1, N = 4 | 99 cps | 100 cps | 99 cps | 100 cps |
| M = 1, N = 5 | 91 cps | 87 cps | 91 cps | 93 cps |
| M = 1, N = 6 | 106 cps | 104 cps | 105 cps | 115 cps |

Many other sources, References [20] - [47], were consulted for analytical and experimental information. Detailed correlation with these sources was not attempted since the layered composite capability could best be explored further through our test program.

3.3.1 Fuselage Program Tests

The specimens and fixture used for the Fuselage Program tests were described in Sections 3.1.1 and 3.2.1. The setup of equipment for the vibration tests is shown in Figures 48 and 49. The panel specimens were tested in the fully clamped boundary condition.

In the vibration tests the axial load was maintained at 100 pounds while the panel was tapped with a cardboard cylinder to set the panel vibrating at its resonant frequency. This frequency was monitored by the following equipment. The transducer was a one gram MB Electric Velocity Pickup (Model 115) connected to a Tektronix, Storage type Oscilloscope (Model 549). Incorporated in the system was a Krohn-Hite Variable Band Filter to obtain the frequency output within the ranges of interest. Photographs of the oscilloscope traces were made with a Hewlett-Packard Camera (Model 197A). These photographs constituted the data output of the system.

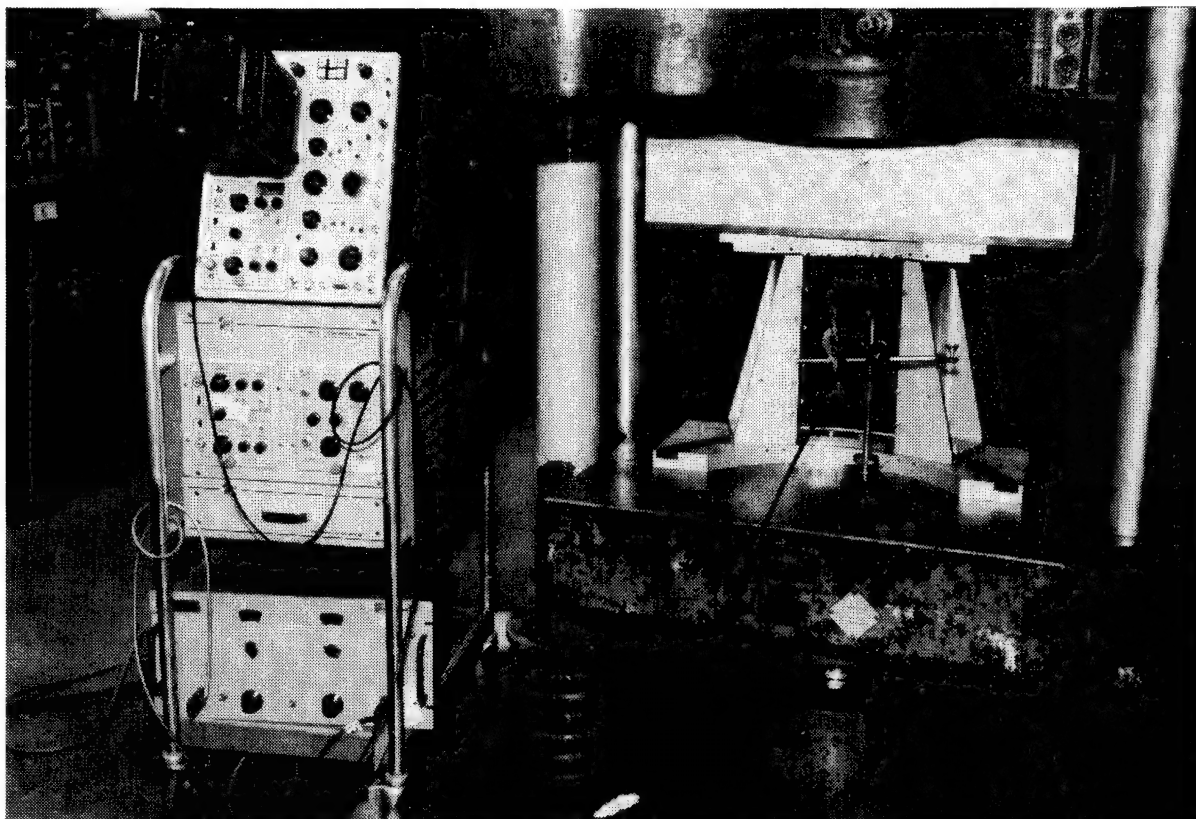


Figure 48 Test Setup and Instrumentation for Vibration Tests

SMD7074

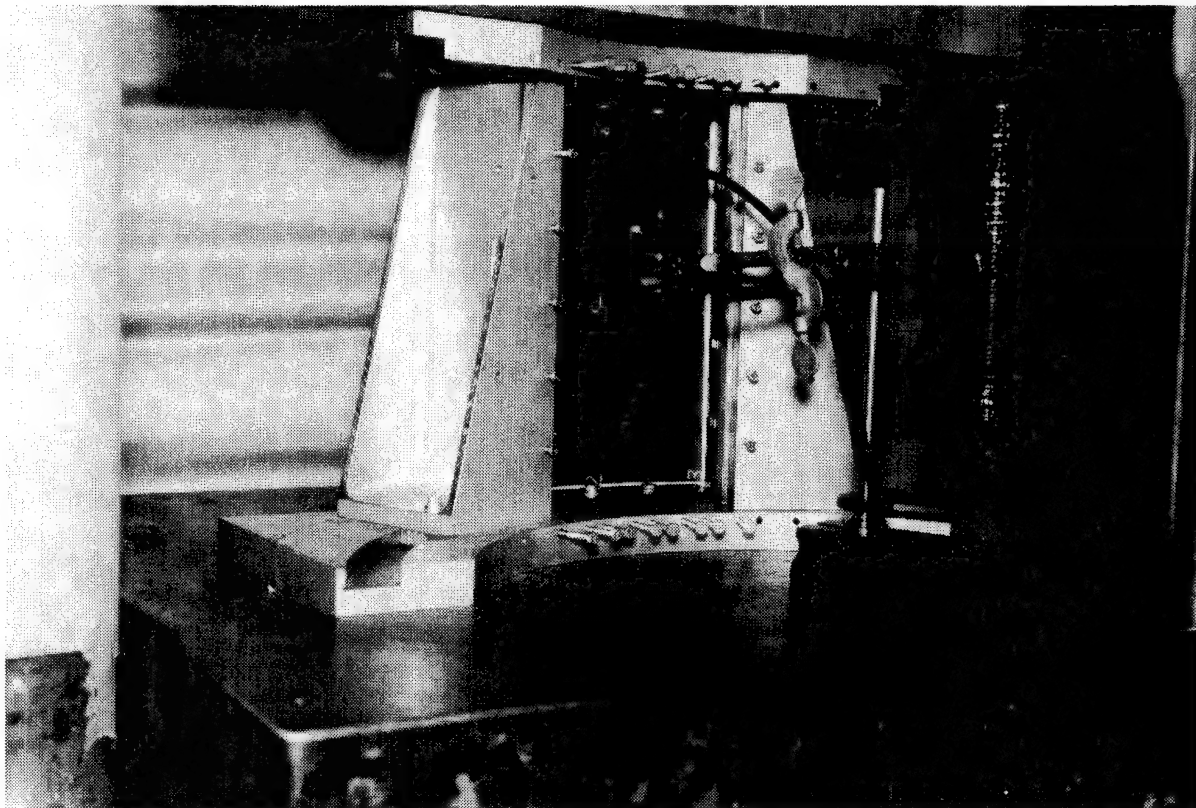


Figure 49 Vibration Setup Showing Closeup of Velocity Transducer

Typical photographs obtained during the vibration tests are included in Figure 50. All the photographs are given in Reference [7]. The fundamental frequency was obtained from these pictures using the following conversion formula:

$$\omega_o = \frac{N}{dRK}, \text{ cycles/record}$$

where: ω_o = fundamental frequency,

N = number of cycles counted,

d = distance on photograph to include N cycles,

R = ratio of object to image size to correct for photographic reproduction, and

K = constant set in on oscilloscope, seconds/cm

The actual process for measuring the distances on the photograph and converting the results, was accomplished on the Hewlett-Packard Data Reduction equipment. The final results are tabulated in Table VIII. The table shows panel number, laminate, the percent difference between experimental and results obtained using a 10 in.-lb./rad/in. elastic restraint on the straight sides, and the natural frequencies, including the clamped curved edge, simply supported straight edge classical results. The results show that the actual side support restraint makes a great deal of difference in the results.

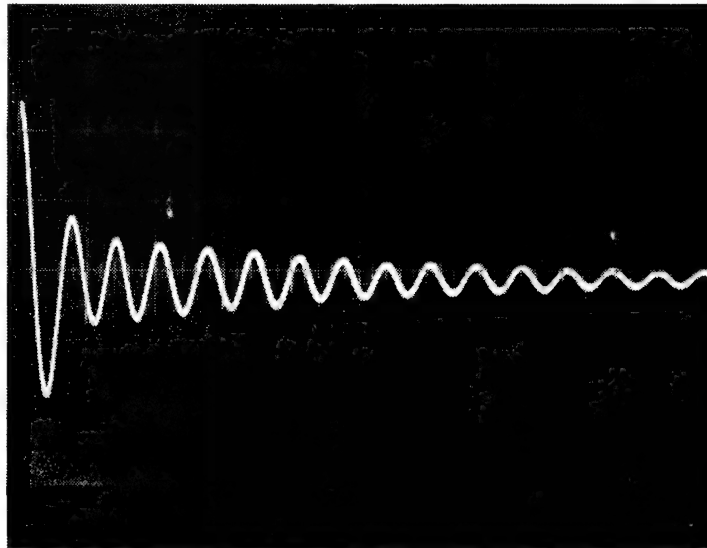
3.3.2 Dynamic Characteristics Program Tests

Some of the tests of Reference [13] were described in Section 3.1.2. The program also included tests of stiffened curved panels, unstiffened cylinders, and a stiffened cylinder.

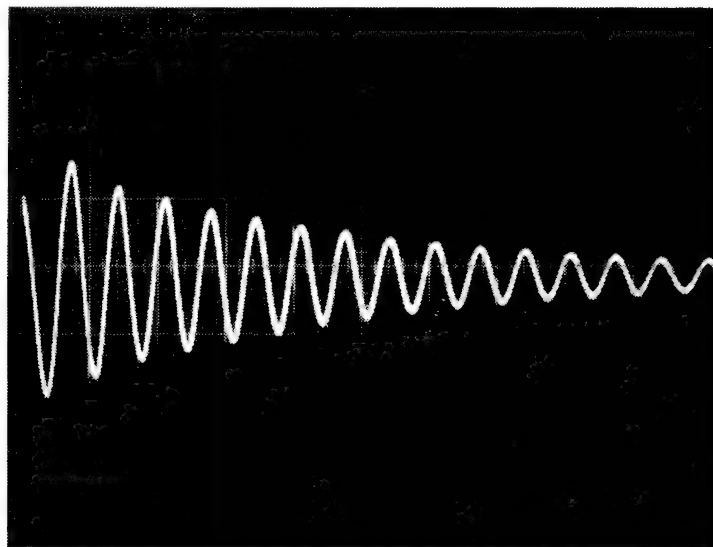
3.3.2.1 Cantilever Curved Panels

The specimens are described in Section 3.1.2 and shown in Figures 14-16. The specimens are designated 15, 16A, and 16B and have 15-inch spans and 24-ply, $[0/+45_4/90]_c$ laminates. Specimen 15 has a 15-inch chord and a 36-inch radius, while Specimens 16A and 16B have 6-inch chords and 36- and 12-inch radii, respectively.

Frequencies and mode shapes have been determined experimentally for the first six natural modes.



Panel 49A, Mode 1, 1



Panel 49A, Mode 1, 2

Figure 50 Velocity Traces for Panel 49A

Table VIII FUSELAGE PROGRAM VIBRATION TEST RESULTS

| PANEL | LAYUP | % DIFF EXP-E.R. | MODE 1 | | MODE 2 | | |
|-------|------------|--------------------|-------------------------|--------------------------|------------|--------------------------|-------------------|
| | | | NATURAL FREQUENCIES, HZ | | EXPER. | ELAST. RES. C-C-ER-ER | CLASSICAL CCSS |
| | | | EXPER. | ELAST. RES. C-C-ER-ER | | | |
| 19A | [+45] 2s | + 1.3 | 771 (1, 2) | 781 | | | |
| 19D | [+45] 2s | + 2.2 | 772 (1, 2) | 789 | | | |
| 21A | [0, 90] s | +13.1 | 335 (1, 3) | 379 | 415 (1, 2) | 342 | 392 |
| 23E | [+45] s | + 7.4 | 486 (1, 3) | 522 | | | |
| 29E | [+45] 3s | +12.3 | 729 (1, 2) | 819 | | | |
| 33E | [+45] 4s | + 4.5 | 583 (1, 2) | 609 | | | |
| 35A | [+45] 6s | + 7.4 | 702 (1, 2) | 754 | | | |
| 39A | [-30] 4s | + 8.1 | 595 (1, 2) | 643 | 635 (1, 3) | 726 | 780 |
| 41A | [-30] 6s | 0 | 707 (1, 2) | 707 | | | |
| 45E | [0] 4s | - 5.4 | 423 (1, 2) | 400 | | | |
| 49A | [0, 90] 3s | + 2.6 | 707 (1, 2) | 720 | 708 (1, 1) | 633 | 782 |
| 51A | [+30] s | + 8.2 | 451 (1, 3) | 488 | | | |
| 53A | [+30] 2s | + 6.5 | 634 (1, 3) | 675 | 637 (1, 2) | 683 | 739 |
| 55A | [+30] 3s | +11.9 | 649 (1, 2) | 726 | | | |
| 59A | [0, +60] s | + 8.9 | 514 (1, 3) | 560 | 573 (1, 2) | 569 | 613 |

Preliminary analyses were performed with the DRR curved panel analysis procedure (SS8). Post-test analyses were performed with the USA procedure and NASTRAN. All of the analyses included stacking sequence effects. The test-theory correlation data for natural frequencies is shown in Table IX. As seen in the table, the DRR analysis is in good agreement for the bending modes, which are dominated by the spanwise stiffness. However, the effect of curvature on the torsional stiffness is evidently being over-predicted in each case, thereby raising the frequencies for the torsion modes. Although several possible causes for the discrepancies have been investigated, no satisfactory explanation has yet been found for the failure of the DRR procedure to correctly model the torsional stiffness.

The opposite is true for the finite-element procedures. That is, the USA and NASTRAN analyses of Specimen 16B are modeling the torsional stiffness accurately, but they are overestimating the spanwise stiffness. Both simulations used piecewise flat element systems to model the structure. The torsional modes are not greatly affected by the curvature, but the curvature effects dominate the bending deflections. Therefore, the discrepancies reflect an inadequate representation of the specimen curvature. The superiority of the USA analysis to the NASTRAN analysis is caused by the larger number of elements used.

The agreement for Specimen 16A was greatly improved for both the DRR and USA analyses. The DRR analysis overpredicted the first torsional frequency, and the USA analysis overpredicted the bending stiffness for the fundamental mode and the influence coefficients. The superior agreement is caused by the relatively narrow chord and low curvature.

The USA analysis of Specimen 15 follows the previously noted trends in that it correctly predicts the first torsional frequency and accurately predicts all of the mode shapes. In this case, the first bending mode frequency and all subsequent frequencies were predicted to be lower than measured. The simulation used was an equivalent thickness and stiffness sandwich model with 11 spars and 16 ribs. Skin elements were flat, constant stress triangles. Agreement is not as good as it is for Specimen 16A although the curvatures are the same. The increased chord width and included angle increased curvature effects and made the specimen more difficult to analyze with flat elements.

Also included in the results is a DRR analysis of Specimen 16 as a flat panel for comparison purposes. Percent differences for 16A and 16B are shown to demonstrate the effect of curvature.

Table IX NATURAL FREQUENCIES FOR
CURVED PANELS

| SPEC. NO. | METHOD | FREQUENCY (Hz) | | | | | | AVERAGE % ERROR |
|--------------|--------|----------------|-----|-----|-----|-----|-----|--------------------|
| | | 1 | 2 | 3 | 4 | 5 | 6 | |
| 15 | Mode | T | B | T | C | C | C | |
| | DRR | 86.0 | 107 | 226 | 293 | 313 | 459 | 21.6 |
| | EXP | 61.0 | 94 | 178 | 246 | 271 | 405 | -- |
| 16* | Mode | B | T | B | T | B | C | |
| | DRR | 18.2 | 101 | 127 | 292 | 385 | 550 | -- |
| 16A | Mode | B | T | B | T | B | C | |
| | DRR | 27.8 | 123 | 163 | 344 | 438 | 609 | 4.57 |
| | USA | 29.2 | 110 | 155 | 319 | 396 | 551 | 5.97 |
| | EXP | 26.7 | 107 | 163 | 330 | 435 | 589 | |
| 16B | Mode | B | T | B | T | C | B | |
| | DRR | 64.5 | 187 | 345 | 428 | 754 | 790 | 17.81 |
| | USA | 71.1 | 116 | 320 | 362 | 633 | 667 | 7.78 |
| | NAST | 81.5 | 114 | 418 | 373 | 708 | 846 | 12.93 |
| | EXP | 60.0 | 113 | 337 | 364 | 675 | 773 | -- |

Modes: T = Torsion, B = Bending, C = Coupled

*Analysis of 16 as a flat plate for comparison purposes -
not a test specimen.

3.3.2.2 Stiffened Panels

Free-free natural frequencies and mode shapes were measured for four stiffened panels, Specimens 33 through 36. One flat panel and one curved panel were fabricated. Each panel was 18 inches wide and 36 inches long, and the curved panel had a radius of 36 inches. Each panel was made of 12 plies of boron-epoxy oriented at $\pm 45/90$ degrees, resulting in plate bending stiffnesses $D_{11} = 155$, $D_{22} = 330$, and $D_{66} = 116 \text{ lb.-in}^2/\text{in.}$ Specimens 33 and 35 (curved) have three aluminum channel stiffeners bonded to one side at the interior quarter points.

Each stiffener has a cross-sectional area of 0.07625 in.^2 and $EI = 9508 \text{ lb.-in.}^2$ about the centroid. Specimens 34 and 36 were made by bonding two additional stiffeners to the edges of Specimens 33 and 35 after they were tested. The specimens were suspended horizontally with surgical tubing attached to one side along the panel length; this tubing was located nine inches from each end. The rigid body frequencies of the panel were one Hz or less.

To determine the validity of the experimental boundary conditions, Specimen 33 was also tested with the panel suspended vertically. The supports were attached to one end and were located five inches from each side. Frequencies and mode shapes were the same as those measured with the panel suspended horizontally.

Available analytical and test results for the stiffened panels are given in Table X. DRR results are shown for the flat panels, Specimens 33 and 34, and for the same panel without stiffeners for comparison. Acceptable analytical results for the curved specimens were not generated because of problems with the DRR shell analysis procedure SS8. Experimental results are shown for the lowest seven to nine natural frequencies detected. Analytical results for the flat plate are not complete in that some higher mode shapes had frequencies lower than some of those shown. Agreement was excellent between the experimental and analytical natural frequencies and mode shapes for the flat stiffened panels.

3.3.2.3 Unstiffened Composite Cylinders

Two unstiffened cylinders, 15 inches in diameter and 16 inches in length, were designed to study the accuracy of the Rayleigh-Ritz shell procedure SS8 for full cylinders.

Table X NATURAL FREQUENCIES (Hz) FOR STIFFENED PANELS

| MODE | FLAT PLATE | SPECIMEN 33 | | | SPECIMEN 34 | | | SPEC 35 | | SPEC 36 | |
|--------------|---------------|-------------|------|------|-------------|------|------|---------|-------|---------|-------|
| | DRR | EXP | DRR | P.E. | EXP | DRR | P.E. | EXP | | EXP | |
| 2,0 | 8.8 | 39.8 | 40.1 | 0.8 | 48.4 | 48.0 | -0.8 | -- | -- | -- | -- |
| 3,0 | 25.1 | 95.7 | 100 | 4.5 | 126 | 129 | 2.4 | -- | -- | -- | -- |
| 4,0 | 48.9 | -- | 162 | -- | -- | 250 | -- | -- | -- | -- | -- |
| 1,1 | 17.0 | 18.1 | 17.1 | -5.5 | 16.2 | 15.1 | -6.8 | 19.6 | 18.3 | 18.3 | 18.3 |
| 2,1 | 36.0 | 48.2 | 48.3 | 0.2 | 59.2 | 59.6 | 0.7 | 78.0 | 76.0 | 76.0 | 76.0 |
| 3,1 | 61.7 | -- | 101 | -- | -- | 146 | -- | -- | 169.4 | 169.4 | 169.4 |
| 4,1 | 87.7 | -- | 155 | -- | -- | 271 | -- | -- | -- | -- | -- |
| 0,2 | 57.8 | 54.5 | 54.3 | -0.4 | 41.5 | 43.7 | 5.3 | 53.2 | 43.5 | 43.5 | 43.5 |
| 1,2 | 67.8 | 61.4 | 63.6 | 3.6 | 54.0 | 53.4 | -1.1 | 63.8 | 56.4 | 56.4 | 56.4 |
| 2,2 | 92.9 | 93.6 | 93.2 | -0.4 | 105.3 | 97.6 | -8.2 | 84.8 | 82.6 | 82.6 | 82.6 |
| 3,2 | 129.2 | -- | 157 | -- | -- | 189 | -- | 140.8 | -- | -- | -- |
| 0,3 | 158.9 | -- | 143 | -- | 120 | 122 | 1.7 | 144.1 | 121.6 | 121.6 | 121.6 |
| 1,3 | 164.2 | -- | 152 | -- | 142 | 130 | -8.4 | -- | -- | -- | -- |
| 2,3 | 193.2 | -- | 188 | -- | -- | 164 | -- | -- | 198.3 | 198.3 | 198.3 |
| AVERAGE P.E. | | -- | -- | 2.2 | -- | -- | 3.9 | -- | -- | -- | -- |

Specimen 37 has six plies of boron-epoxy oriented at $0/\pm 45$ degrees, and Specimen 38 has four plies of boron-epoxy oriented at ± 45 degrees. Frequencies, mode shapes, and damping coefficients were determined for the natural modes of the specimen corresponding to longitudinal mode $m = 0, 1, 2$ and the frequency sweep from 0 to 525 Hz. The specimens were tested with free-free boundary conditions as shown in Figures 51-53.

The frequency correlations are shown in Table XI and Figures 54 and 55. The actual cylinder properties and the predicted properties are given in Table XII. Agreement is good everywhere except the $m = 2$ modes for Specimen 38. Although the lamina modulus in the fiber direction was increased from 30×10^6 psi to 33.7×10^6 psi to account for the apparent high fiber volume fraction, the reduction in thickness of the shell brought about a 10 percent lower longitudinal stiffness than predicted. This resulted in lower frequencies.

3.3.2.4 Stiffened Composite Cylinders

Specimen 39, which is the graphite-epoxy stiffened shell shown in Figure 56, and in Figure 57 with an unstiffened cylinder, was fabricated and dynamic tested to study the accuracy of the DRR procedure SS8 for shells with stiffeners. This specimen is 24 inches in diameter and 30 inches in length with an 8-ply graphite shell with orientations of ± 45 degrees. The plate bending stiffnesses for the shell are $D_{11} = D_{22} = 97$ and $D_{66} = 80$ lb-in²/in. The shell is stiffened by four equally spaced aluminum external longitudinal stringers with $EI = 2.3 \times 10^6$ lb-in.², two graphite internal rings at one-third and two-thirds of the length with $EI = 6.4 \times 10^5$ lb-in.², and two aluminum external rings at the ends with $EI = 1.6 \times 10^6$ lb-in.². Stiffener EI's were calculated about their centroids.

Attempts to analyze this cylinder with Procedure SS8 were unsuccessful. Analytical results were simply not reasonable for this specimen. To determine if the problem was numerical in origin, Procedure SS8 was converted to double precision, but there was no change in the results. The problem is probably in the ring stiffener formulation, but no error could be found. Therefore, there are no analytical results for this specimen.

The natural frequencies and descriptions of the mode shapes determined experimentally are shown in Table XIII. The stiffened cylinder was tested with free-free boundary conditions. The technique used was the same as that used on the unstiffened cylinders.

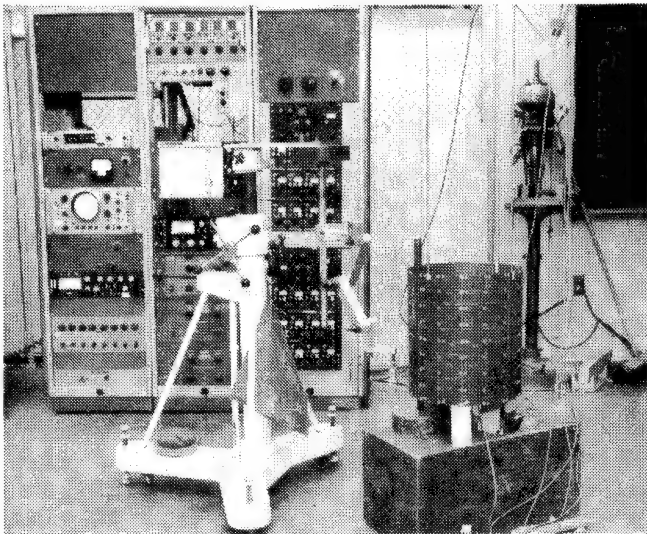


Figure 51 Dynamic Testing of a Cylinder

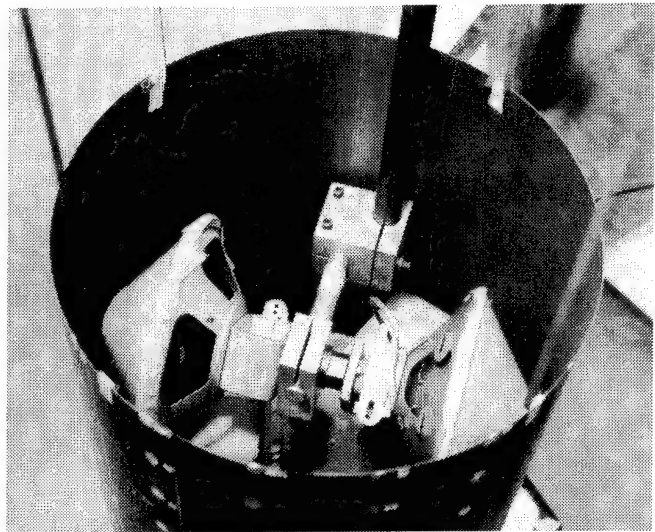


Figure 52 Dynamic Excitation of a Cylinder

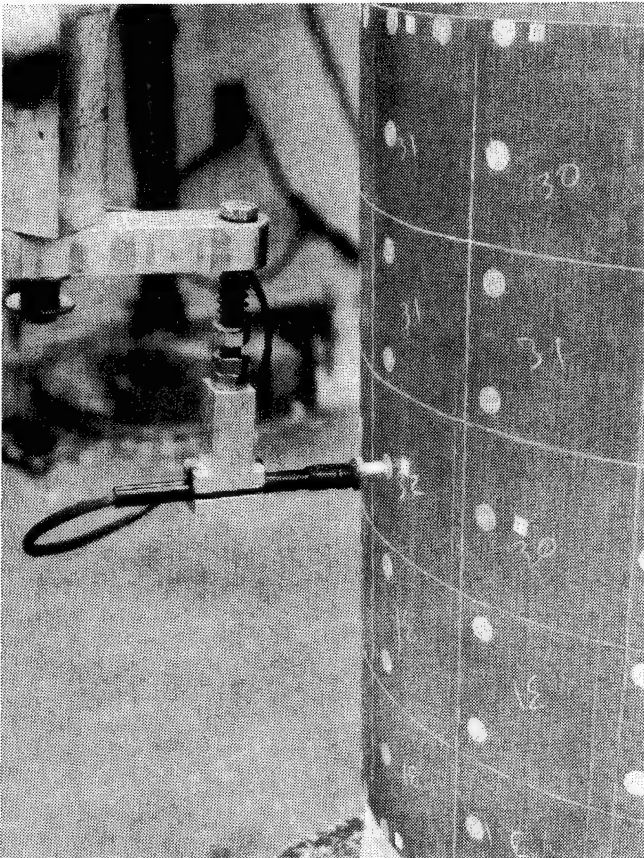


Figure 53 Modal Deflection Measurement

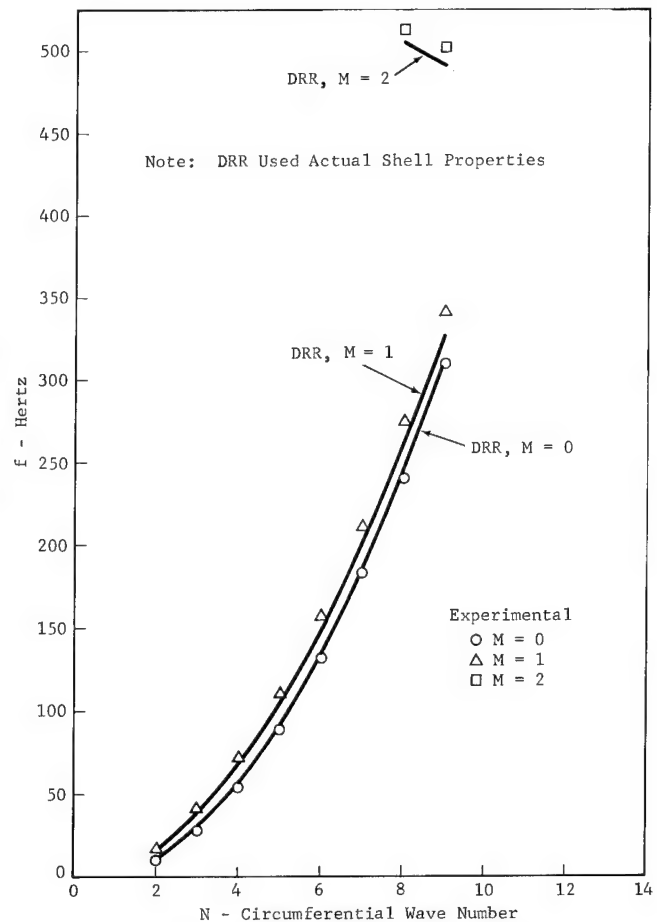


Figure 54 Frequency Correlation for Specimen 37

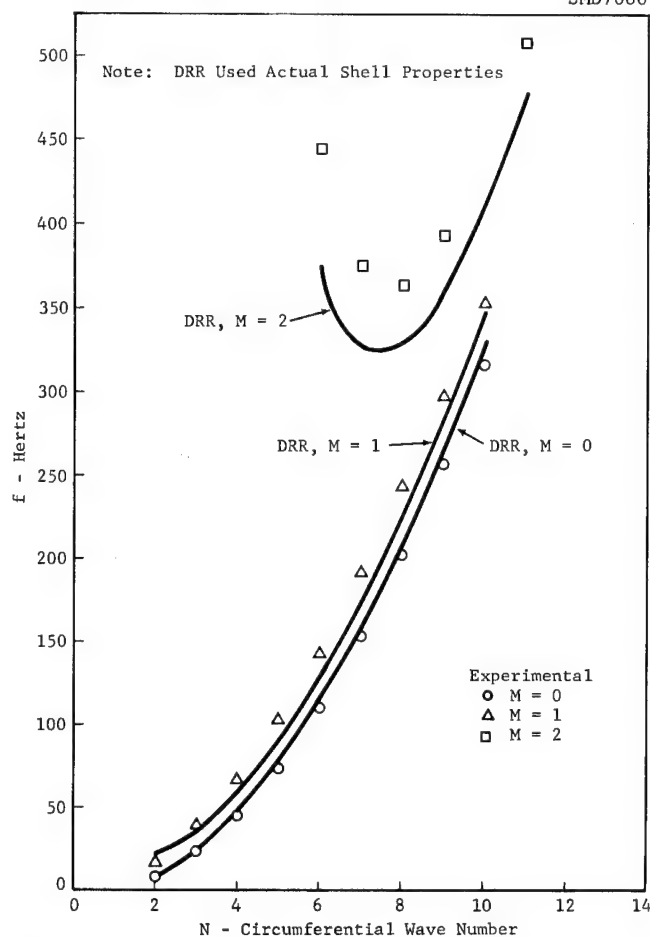


Figure 55 Frequency Correlation for Specimen 38

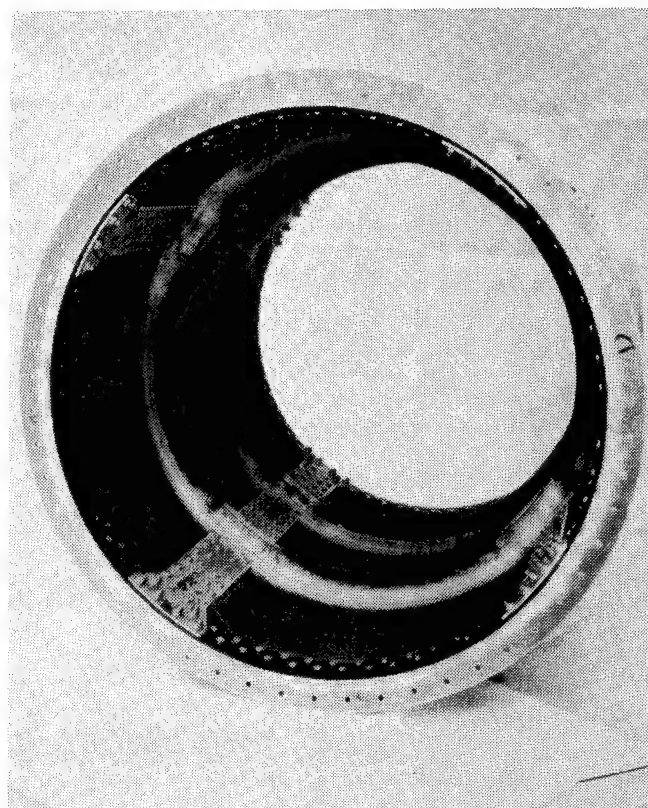


Figure 56 Graphite-Epoxy Stiffened Shell

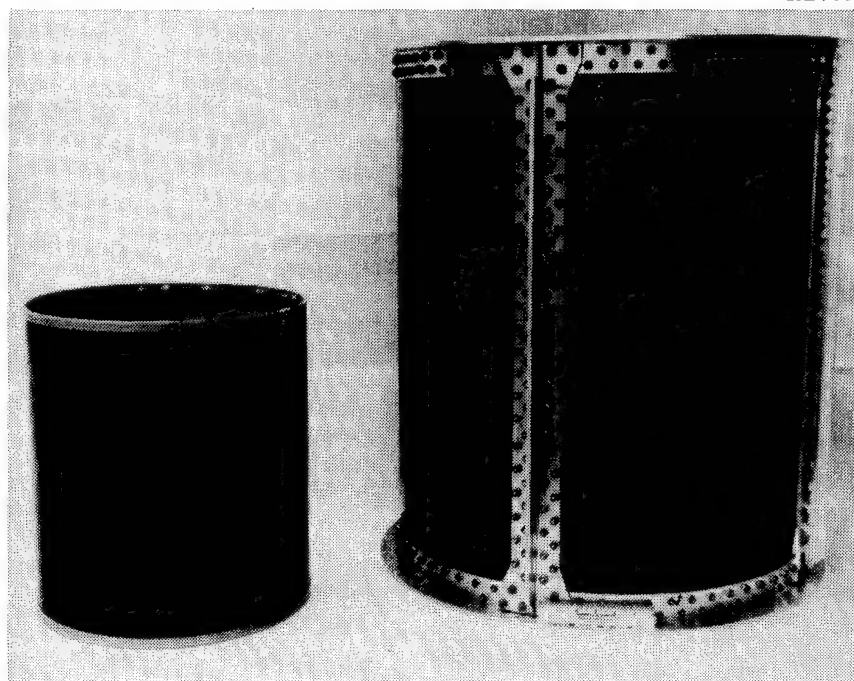


Figure 57 Stiffened and Unstiffened Cylinders

Table XI NATURAL FREQUENCIES (Hz) FOR UNSTIFFENED CYLINDERS

| MODE | SPECIMEN 37 | | | SPECIMEN 38 | | |
|-----------|-------------|------|------|-------------|------|-------|
| | EXP | DRR | P.E. | EXP | DRR | P.E. |
| 0,2 | 9.8 | 10.5 | 7.1 | 8.0 | 8.2 | 2.5 |
| 0,3 | 27.9 | 30.3 | 8.6 | 22.8 | 24.5 | 7.5 |
| 0,4 | 54.2 | 57.8 | 6.6 | 45.0 | 48.8 | 8.4 |
| 0,5 | 89.3 | 93.2 | 4.4 | 74.1 | 79.2 | 6.9 |
| 0,6 | 132 | 137 | 3.8 | 110 | 116 | 5.4 |
| 0,7 | 183 | 188 | 2.7 | 153 | 160 | 4.6 |
| 0,8 | 240 | 248 | 3.3 | 202 | 210 | 4.0 |
| 0,9 | 310 | 315 | 1.6 | 256 | 267 | 4.3 |
| 0,10 | -- | -- | -- | 316 | 331 | 4.8 |
| 1,2 | 17.3 | 15.9 | -8.1 | 15.5 | 22.7 | 37.6 |
| 1,3 | 41.5 | 38.5 | -7.2 | 38.8 | 36.1 | -7.0 |
| 1,4 | 72.9 | 68.0 | -6.7 | 66.6 | 60.1 | -9.8 |
| 1,5 | 111 | 104 | -6.3 | 103 | 92.7 | -10.0 |
| 1,6 | 157 | 148 | -5.7 | 143 | 130 | -9.1 |
| 1,7 | 211 | 200 | -5.2 | 191 | 175 | -8.4 |
| 1,8 | 274 | 260 | -5.1 | 243 | 225 | -7.4 |
| 1,9 | 341 | 327 | -4.1 | 297 | 283 | -4.7 |
| 1,10 | -- | -- | -- | 353 | 347 | -1.7 |
| 2,6 | -- | -- | -- | 444 | 374 | -15.8 |
| 2,7 | -- | -- | -- | 375 | 327 | -12.8 |
| 2,8 | 513 | 506 | -1.4 | 363 | 329 | -9.4 |
| 2,9 | 502 | 491 | -2.2 | 392 | 362 | -7.6 |
| 2,10 | -- | -- | -- | -- | 414 | -- |
| 2,11 | -- | -- | -- | 508 | 478 | -5.9 |
| Avg. P.E. | -- | -- | 5.0 | -- | -- | 8.5 |

Table XII CYLINDER PROPERTIES

| Property | Specimen 37 | | Specimen 38 | |
|----------------|-------------|---------|-------------|--------|
| | Theory | Actual | Theory | Actual |
| W, lb. | 1.648 | 1.678 | 1.099 | 1.089 |
| t, in. | 0.0312 | 0.03092 | 0.0208 | 0.0185 |
| <i>l</i> , in. | 16.0 | 16.0 | 16.0 | 16.0 |
| R, in. | 7.5 | 7.5 | 7.5 | 7.5 |

Table XIII STIFFENED CYLINDER FREQUENCIES (Hz)

| Frequency | Damping | Mode |
|-----------|---------|-----------------------------------|
| 129 | .004 | 0,2 Nodes between stringers |
| 152 | .004 | 0,2 Nodes at stringers |
| 362 | .012 | 0,3 |
| 384 | .008 | 1,3 |
| 498 | .008 | 0,4 |
| 508 | .110 | 2,3 Nodes at internal rings (1/3) |
| 550 | .018 | 2,2 |
| 582 | .044 | 2,3 Nodes 20% from ends |
| 589 | .014 | 1,4 |
| 716 | .070 | 2,2 & 6 |
| 735 | -- | -- 1st mode for center panels |
| 933 | .009 | -- Not identifiable |
| 967 | .009 | 3,4 |
| 1275 | .017 | 4,2 |

S E C T I O N I V

S U M M A R Y

A Rayleigh-Ritz analysis for laminated anisotropic cylindrically curved shells has been performed. The analysis is formulated to solve static deflection, buckling, and natural vibration problems. Discrete energy contributions from stringers, rings, lumped masses, point loads, point and line moments, point and line springs, and elastic moment restraints have been included.

Digital computer Procedure SS8 has been written to compute the solutions to the above problems. The program has some limitations, mainly in regard to its treatment of free edges of a panel. The treatment of imperfection sensitivity in buckling should not be regarded as a final answer to the difficult problem of knockdown factors in compression, but did show promise. An assessment of the accuracy of the discrete ring stiffening capability was clouded by the problem of free edges. It is felt that the program serves a useful function as written, but that it needs more development work in certain areas.

Also described are various tests on curved panels and cylinders which in most cases were first attempts to discern the effects of curvature and anisotropy in laminated composites. Several interesting test methods were developed, including two applications of the Southwell method and an application of the Moire grid shadow technique.

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A P P E N D I X I

DESCRIPTION OF PROCEDURE SS8

The analysis described in Section II has been programed as IBM 370 Procedure SS8. Due to the large size of the program, a one-level, four-element overlay tree is used. The tree is shown in Figure 58. The longest resulting path is 418K bytes. All the subroutines are compiled under FORTRAN H, option 2, except subroutine ASEMBL, which is compiled with FORTRAN G.

Subroutines GSTART, PROB, SKIPPR, STATUS, and FREEFD are General Dynamics System Subroutines which perform I/O and timing functions. They would not be used elsewhere and are not discussed further. All other subroutines marked CF in Figure 58 are system-resident mathematical subroutines for matrix inversion or eigenvalue solutions. The purposes of the specially-written subroutines for SS8 are described below.

Main Program

The main program for SS8 serves only as a controller for implementing the necessary overlays. A blank common area and the labelled common blocks "CHECKS", "CNTROL", "NUMBER", "GEOM", "\$TIME", "ABD", "PARAM", "VALUES", "ARRAYS", "BLOCK", "STFVAL", and "FLEXBL" are used for communication between overlays.

Subroutine READ

This subroutine reads all input data, based on the requirements of the problem, checks the input data, and does some preliminary calculations.

Subroutine CYLNDR

This subroutine calculates the appropriate running loads to be used when a force, torque, or bending moment is applied to a full cylinder. It should be noted that due to the uncoupling of

MAIN 'A'
 BLANK (C.B.)
 BLOCK (C.B.)
 ARRAYS (C.B.)
 VALUES (C.B.)
 CNTROL (C.B.)
 NUMBER (C.B.)
 GEOM (C.B.)
 \$TIME (C.B.)
 ABD (C.B.)
 PARAM (C.B.)
 CHECKS (C.B.)
 STFVAL (C.B.)
 FLEXBL (C.B.)
 GS\$TART (CF)
 PROB (CF)
 SKIPPR (CF)
 STATUS (CF)

- C.B. Denotes Common Block
- CF Denotes System Subroutines;
- ' ' Denotes Deck Identification Letter

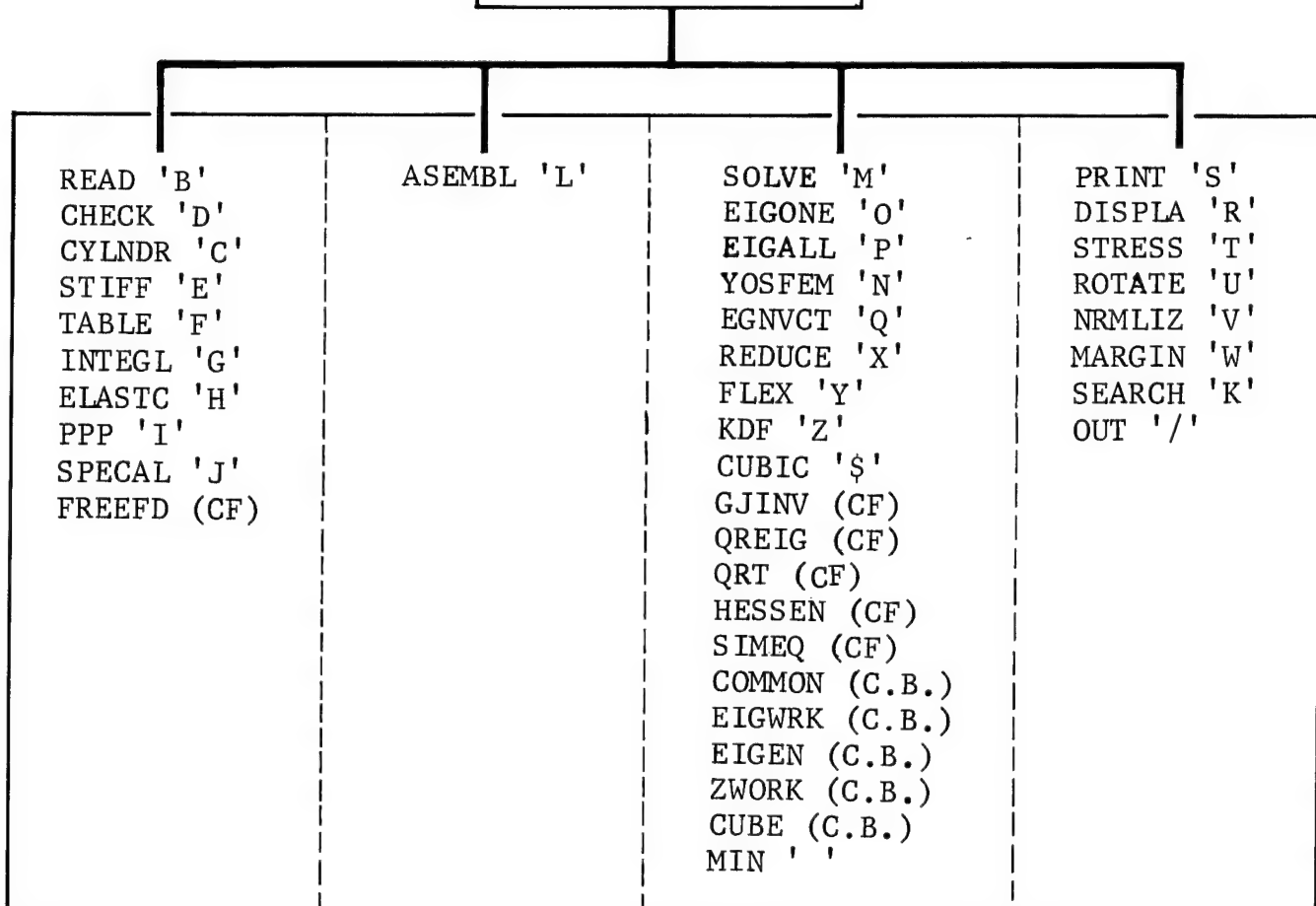


Figure 58 SS8 Overlay Structure

the axial and circumferential assumed mode shapes, torsional buckling results are not possible with SS8.

Subroutine CHECK

This subroutine writes a message and sets an error flag when subroutine READ detects an input error.

Subroutine STIFF

This subroutine calculates the A, B, and D stiffness terms as defined in Reference [3], and implemented in References [1] and [48], for a laminated plate.

Subroutine TABLE

This subroutine controls the calculation of the necessary integral tables of assumed modes in the x and y-directions.

Subroutine INTEGL

This subroutine, adapted from Reference [1], uses a highly efficient algorithm for calculating the necessary beam-mode integrals. By calling PPP and SPECAL, it calculates the single function integrals and the special cases for free-free and simple-free boundary conditions. At 625 points on the normalized shell surface, it calculates the value of the mode functions and their derivatives. At any stiffener locations, it calculates integrals, mode functions and derivatives.

Subroutine SPECAL

This subroutine calculates the integrals and mode constants for the simple-free and free-free boundary conditions.

Subroutine ELASTC

This subroutine implements the elastic moment restraint boundary condition by calculating the beam-mode constants which are dictated by the input moment restraint.

Subroutine PPP

This subroutine calculates the single-function beam-mode integrals.

Subroutine ASEMBL

Based on the input geometry and material properties and the calculated integrals, this subroutine assembles the matrices of potential energy, kinetic energy, lateral loads, and edge loads as required by the problem being performed. This assembly is done in submatrix fashion representing u, v, and w partitions.

Subroutine SOLVE

This subroutine uses the matrices from ASEMBL to solve the appropriate eigenvalue problem or simultaneous equations. It makes use of subroutines ARRAY, NROOT, and EIGEN from the IBM Scientific Subroutine Package.

Subroutine YOSFEM

This subroutine was written to perform multiplication of two large matrices by using a minimum amount of extra core storage. Optionally the product matrix may be stored in the premultiplier matrix or the postmultiplier matrix.

Subroutine EIGONE

For a single eigenvalue and eigenvector solution, the power method is an efficient algorithm. This method is used when a single buckling eigenvalue or frequency is desired.

Subroutine EIGALL

This subroutine finds all the eigenvalues of the matrix using the QR transform. The algorithm is programmed into three Convair Aerospace resident subroutines, HESSEN, QREIG, and QRT. Once the eigenvalues are found, the desired number of eigenvectors are found using a matrix decomposition technique in Subroutine EGNVCT.

Subroutine EGNVCT

Using the original matrix and a known eigenvalue, this routine uses matrix decomposition to find the corresponding eigenvector.

Subroutine PRINT

This subroutine performs various output functions, such as finding the dominant term in an eigenvector, calculating the problem execution time, and controlling other output subroutines.

Subroutine DISPLA

This subroutine calculates and prints deflections, curvatures, moments, shears, and edge reactions. All but edge reactions are printed at 625 equally-spaced points on the developed shell planform.

Subroutine OUT

This subroutine transforms the output arrays into a form for efficient printing.

Subroutine STRESS

This subroutine calculates stresses and strains at the 625 grid points.

Subroutine NRMLIZ

This subroutine finds the largest value in each output array and normalizes with respect to it.

Subroutine ROTATE

This subroutine performs a strain transformation of coordinates from one angle to another. It is used to check margins of safety in various directions.

Subroutine MARGIN

This subroutine calculates margins of safety according to the maximum strain theory of failure.

Subroutine SEARCH

This subroutine keeps track of the minimum margin of safety as well as its mode and location.

Subroutine FLEX

It is often desirable to determine an influence coefficient or flexibility matrix for a structure being analyzed. Since all of the problem types under consideration contain a term

$$[V] \{a\}$$

where $[V]$ is the varied strain energy density or the structural stiffness matrix in the generalized coordinates a_{imn} .

To obtain the point force-displacement flexibility matrix, the $[V]$ matrix must first be partially inverted to produce the lateral stiffness matrix $[S]$ in terms of the generalized lateral coordinates a_{3mn} . The stiffness matrix $[S]$ may then be inverted and transformed from shape to point coordinates. The transformation matrix can be found from the expression for the lateral displacement at a point:

$$\delta_i = \sum_m \sum_n a_{3mn} X_{3m}(x_i) Y_{3n}(y_i)$$

where (x_i, y_i) are the coordinates of the i^{th} point. For N equations, this may be expressed in matrix form as

$$\{\delta_i\} = [R] \{a\}$$

where $[R]$ is the required transformation matrix. The desired flexibility matrix $[F]$ can then be computed from

$$[F] = [R] [S]^{-1} [R]^T$$

at the N specified control points.

Subroutine REDUCE

This subroutine performs the partial inversion of the matrix containing membrane and bending degrees of freedom to reduce it to only its bending degrees of freedom.

Subroutine KDF

This subroutine uses the analysis of Reference [49] to account for imperfection sensitivity. It is an approximation since the Reference [49] analysis is done for a simply-supported full cylinder and relies on a precise definition of an axisymmetric imperfection. For the purpose of this study, the standard deviation of the thickness over the shell is used as a measure of imperfection, and the knockdown factor for the full cylinder is assumed to apply to any partial cylinder regardless of boundary conditions.

Subroutine CUBIC

This subroutine solves for the lowest real root of a cubic polynomial as required by KDF. This is done by Newton-Raphson iteration for the first root, and then by synthetic division and the quadratic formula for the other two.

Subroutine MIN

This is a general subroutine for determining the smallest element in a vector of values.

Subroutine SWITCH

This subroutine is used in the matrix operations of subroutine SOLVE. It changes diagonal elements in a matrix from 0. to 1. or vice-versa. It is used to prevent the singular matrices (which arise for some problems involving rigid-body modes) from inhibiting a solution.

A P P E N D I X I I

C U S T O M E R I N S T R U C T I O N S F O R S S 8

PROCEDURE SS8

Anisotropic Curved Panel Analysis Program

21 January 1970

D. J. Wilkins

PROBLEM DESCRIPTION

This procedure analyzes cylindrically curved panels with respect to dynamic response, buckling, and static deflection. Vlasov shell theory is used for the formulation and the Rayleigh-Ritz energy method is used for the solution. The integral generation scheme from Procedure RA5 is also employed.

The procedure is capable of analyzing flat plates, cylindrically curved panels, and full cylinders. All combinations of clamped, and simply supported edges, and some combinations of free edges may be specified. Elastic boundary restraint may also be specified.

The material may be isotropic, a laminate of identical orthotropic layers, a laminate of dissimilar orthotropic layers, or a sandwich with orthotropic facings. (No transverse shear effects are included, so that the sandwich analysis is only appropriate for stiff cores.) Discrete, eccentric rings and stringers may be specified.

Edge loads and lateral loads may be specified by up to tenth order polynomials. Point loads, point moments, and line moments may also be used, as well as point and line spring supports. In dynamics, the effects of lumped masses may be included.

In any one problem, the procedure can solve for natural frequencies and mode shapes, or the buckling stress resultants under complicated edge load distributions, or the static deflections (including stresses, strains, and margins of safety) under lateral and edge loads. A flexibility matrix at specified control points may be calculated on any type problem.

INPUT DATA

The program uses "free field" input as explained in the documentation for general purpose subroutine CF619. However, every number input as problem data is considered by the program to be a real number (card type "6" in free field). Therefore, every card of the input deck should have a "6" in column 1. It should be noted that if an input number is an integer, a decimal point is not necessary. The title card (Card No. 1) is not read in the free field mode but it also contains a "6" in column 1.

The general content of each card in a problem deck is as follows:

Column

| | |
|---------|--|
| 1 | The integer "6" |
| 2 -66 | Input data |
| 67 - 72 | The six-digit job number |
| 73 | The letter "P" |
| 74 - 75 | The problem number, beginning with 01 |
| 76 - 79 | The card sequence number, beginning with 0001. |

The input data varies according to the problem being run. A flow chart of the necessary data to run a given problem is shown in Figure 59. One or more cards may be required for each block of data, but each block must begin on a new card.

A description of the data blocks follows:

Block 1. Title

Printed with the output. Any Fortran characters may be used. (1 card only.)

Block 2. IFLAGD, IFLAGB, IFLAGW, IBCX, IBCY, NTX, NTY, ITX, ITY, NMODES, IMATL, NPLYS, IREACT, IOUT, IEDGE, NPNX, NPNY, IPRTN, NQTX, NQTY, IPRTQ, NSTRNG, NRING, NLMASS, NPTLDS, NPTMOM, NLNMOM, NPTSUP, NLNSPR, INTPT, IFLEX (31 integers)

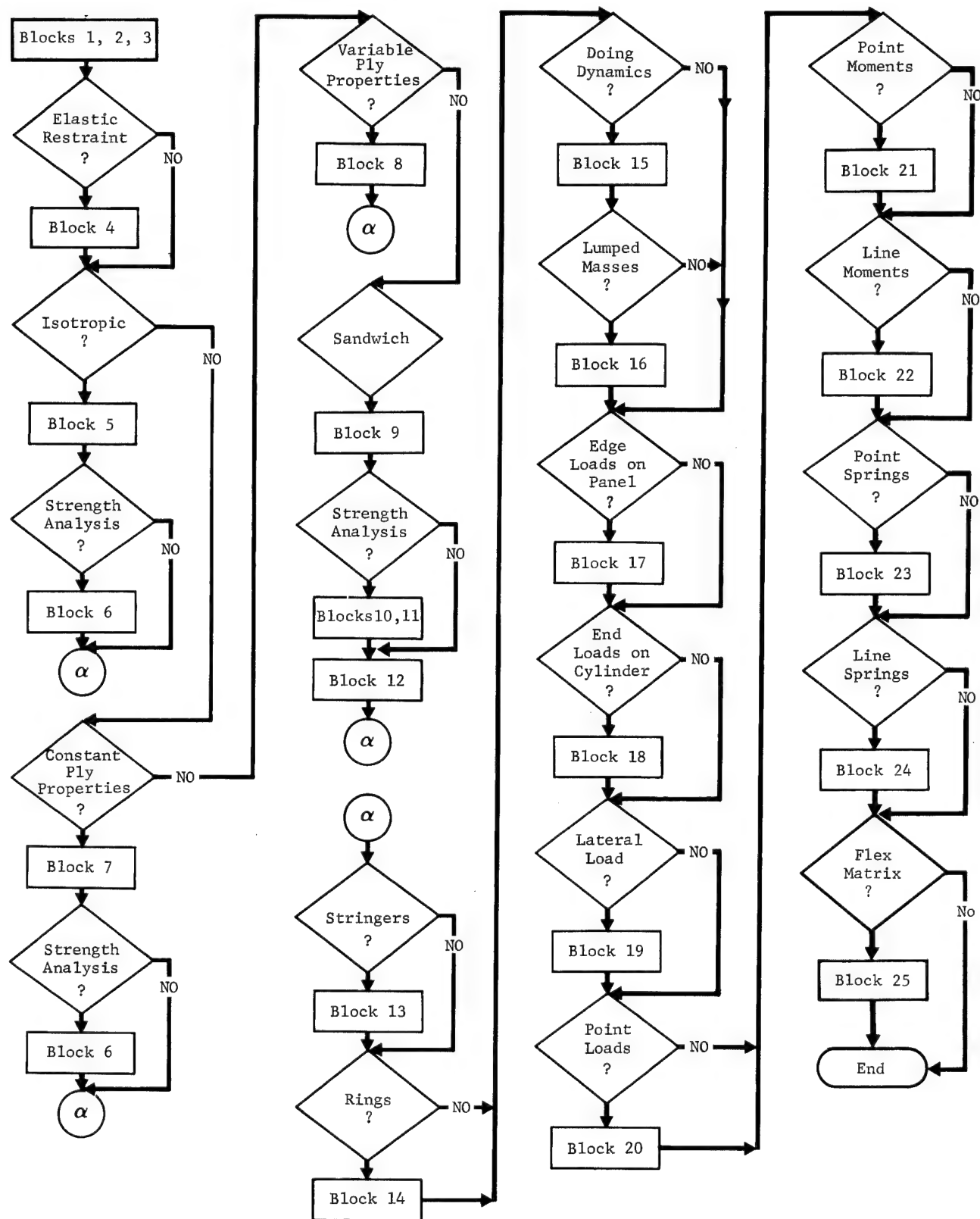


Figure 59 Input Data Flow Chart

IFLAGD = +1, if doing a dynamics problem
 = +0, otherwise.

IFLAGB = +1, if 1 buckling eigenvalue is desired
 = +2, if 2 buckling values are desired
 (as for shear buckling)
 = +3, if 1 buckling eigenvalue and an imperfection sensitivity analysis are desired
 = +4, if 2 buckling eigenvalues and an imperfection sensitivity analysis are desired
 = +0, otherwise.

IFLAGW = +1, if doing a deflection analysis with lateral pressure, q
 = +2, if doing a deflection analysis with no lateral pressure, q
 = +0, otherwise.

IBCX is a tag for the boundary condition in the x-direction.
 = +1, for clamped-simply supported
 = +2, for simply supported-simply supported
 = +3, for clamped-clamped
 = +4, for clamped-free
 = +5, for simply supported-free
 = +6, for free-free
 = +7, for elastic restraint. ($w_{,xx} = \alpha_x w_{,x} \big|_{x=0}$,
 $w_{,xx} = \beta_x w_{,x} \big|_{x=a}$)

IBCY is a tag for the boundary condition in the y-direction.
 = +0, for a full cylinder
 = +1, for clamped-simply supported
 = +2, for simply supported-simply supported
 = +3, for clamped-clamped
 = +4, for clamped-free
 = +5, for simply supported-free
 = +6, for free-free
 = +7, for elastic restraint exactly the same as that in the x-direction
 = +8, other elastic restraint. ($w_{,yy} = \alpha_y w_{,y} \big|_{y=0}$
 $w_{,yy} = \beta_y w_{,y} \big|_{y=b}$)

NTX = Number of terms in the assumed series for
u, v, and w, in the x-direction. $1 \leq \text{NTX} \leq 10$.

NTY = Number of terms in the assumed series for
u, v, and w, in the y-direction. $1 \leq \text{NTY} \leq 10$.

Note: Although the upper limit on each of the above two numbers is ten, the limit on the size of the matrices generated using them is 150. This means that $\text{NTX} * \text{NTY} \leq 50$.

ITX = The beginning term in the assumed series for
u, v, and w. This number sets the range of
m (axial wave number) to be considered in the
analysis, such that $\text{ITX} \leq m \leq \text{ITX} + \text{NTX} - 1$. The
range on ITX is $1 \leq \text{ITX} \leq 20$.

ITY = The beginning term in the assumed series for
u, v, and w. This number sets the range of
n (circumferential wave number) to be considered
in the analysis, such that $\text{ITY} \leq n \leq \text{ITY} + \text{NTY} - 1$.
The range on ITY is $1 \leq \text{ITY} \leq 20$.

NMODES = Number of mode shapes to be calculated in
a natural frequency problem. $1 \leq \text{NMODES} \leq 20$.
= +0, for a buckling or lateral loads problem.

IMATL = +1, for an isotropic material
= +2, for a laminate with constant ply properties
= +3, for a laminate with variable ply properties
= +4, for a sandwich with orthotropic facings.

NPLYS = Number of plies in the laminate
 $1 \leq \text{NPLYS} \leq 40$. For an isotropic material,
NPLYS = +1. For a sandwich, NPLYS = +3.

IREACT = +1 if the reactions (at the corners, or along
the edges of the panel, or at elastic supports)
are desired.
= +0, otherwise.

IOUT = An indicator that controls how much output
is given and also controls whether a lamina
strength analysis is performed. Each of the
following output quantities is printed at 625
points over the panel, with the x = 0 axis
across the top and the y = 0 axis down the
left hand side.

- = +1, for printing the normal deflection, w, only
 - = +2, for printing w, u, and v (mid-surface deflections)
 - = +3, for printing w, u, v, $\epsilon_x^0, \epsilon_y^0, \epsilon_{xy}^0$ (mid-surface strains) and K_x, K_y, K_{xy} (curvatures)
 - = +4, for printing w, u, v, M_x, M_y, M_{xy} (moment resultants), Q_x, Q_y (transverse shear resultants), and $\sigma_x, \sigma_y, \sigma_{xy}$ (stresses, only for isotropic or sandwich)
 - = +5, for printing w, u, v, $M_x, M_y, Q_x, Q_y, \epsilon_x^0, \epsilon_y^0, \epsilon_{xy}^0, K_x, K_y, K_{xy}, \sigma_x, \sigma_y, \sigma_{xy}$
 - = +6, for printing w, $\sigma_x, \sigma_y, \sigma_{xy}$
 - = +7, for printing w, $\epsilon_1, \epsilon_2, \epsilon_{12}$ (strains in lamina axes for each ply), M.S.1, M.S.2, M.S.12 (margins of safety for each ply according to the maximum strain theory)
 - = +8, for printing w, $\sigma_x, \sigma_y, \sigma_{xy}, \epsilon_1, \epsilon_2, \epsilon_{12}, M.S.1, M.S.2, M.S.12$
 - = +9, for printing w, u, v, $M_x, M_y, M_{xy}, Q_x, Q_y, \epsilon_x^0, \epsilon_y^0, \epsilon_{xy}^0, K_x, K_y, K_{xy}, \sigma_x, \sigma_y, \sigma_{xy}, \epsilon_1, \epsilon_2, \epsilon_{12}, M.S.1, M.S.2, M.S.12$.
- IEDGE = +1, if edge loads are to be input
 = +2, if cylinder end loads (force, torque, bending moment are to be input)
 = +0, otherwise.
- NPNX = Number of terms in the edge loads expressions in the x-direction. $1 \leq \text{NPNX} \leq 10$.
 = +0, if IEDGE = +0 or +2.
- NPNY = Number of terms in the edge loads expressions in the y-direction. $1 \leq \text{NPNX} \leq 10$.
 = +0, if IEDGE = +0 or +2.
- IPRTN = +1, if the distributions of the edge loads are to be printed at quarter points of the panel.
 = +0, otherwise.
- NQTX = Number of terms in the distributed lateral loads expression in the x-direction. $1 \leq \text{NQTX} \leq 10$.
 = +0, if IFLAGW = +0 or +2.

NQTY = Number of terms in the distributed lateral loads expression in the y-direction. $1 \leq \text{NQTY} \leq 10$.
 = +0, if IFLAGW = +0 or +2.

IPRTQ = +1, if the distribution of the lateral loads is to be printed at quarter points of the panel.
 = +0, otherwise.

NSTRNG = Number of stringers. $0 \leq \text{NSTRNG} \leq 100$. (For equally-spaced identical stringers, precede number by a minus sign.)

NRING = Number of rings. $0 \leq \text{NRING} \leq 50$. (For equally-spaced identical rings, precede number by a minus sign.)

NLMASS = Number of lumped masses. $0 \leq \text{NLMASS} \leq 50$.

NPTLDS = Number of concentrated normal loads.
 $0 \leq \text{NPTLDS} \leq 50$.

NPTMOM = Number of concentrated point moments.
 $0 \leq \text{NPTMOM} \leq 50$.

NLNMOM = Number of concentrated line moments.
 $0 \leq \text{NLNMOM} \leq 50$.

NPTSUP = Number of point spring supports. $0 \leq \text{NPTSUP} \leq 50$.

NLNSPR = Number of line spring supports. $0 \leq \text{NLNSPR} \leq 50$.

INTPRT = +1, if the values of the calculated integrals, the matrices generated, and detailed timing information is to be printed.
 = +0, otherwise. (Usually, INTPRT = +0).

IFLEX = Number of points for which influence coefficients are desired.

Block 3. AA, [BB], RR, [MU]

AA = Dimension in the x-direction

BB = Dimension in the y-direction (Note: This is not input for a full cylinder.)

RR = Radius of panel.

MU = Standard deviation of panel thickness.

Block 4. [ALFAX, BETAX], [ALFAY, BETAY]

ALFAX = The constant describing the elastic restraint on the edge $x = 0$. $w_{,xx} = (\text{ALFAX})w_{,x}$.

BETAX = The constant describing the elastic restraint on the edge $x = a$. $w_{,xx} = (-\text{BETAX})w_{,x}$.

ALFAY = The constant describing the elastic restraint on the edge $y = 0$. $w_{,yy} = (\text{ALFAY})w_{,y}$.

BETAY = The constant describing the elastic restraint on the edge $y = b$. $w_{,yy} = (-\text{BETAY})w_{,y}$.

The elastic restraint constants are only input as needed, and if the y-direction quantities are identical to those in the x-direction, only ALFAX and BETAX need be input. All of these constants are input as positive for positive restraint.

Block 5. E, ν , T

E = Young's modulus, psi

ν = Poisson's ratio, dimensionless

T = Panel thickness, in.

Block 6. EC (1), EC(2), EC(3), ET(1), ET(2), ET(3)

EC(1) = Compressive strain allowable in the 1-direction, in/in.

EC(2) = Compressive strain allowable in the 2-direction, in/in.

EC(3) = Negative shear strain allowable, in/in.

ET(1) = Tensile strain allowable in the 1-direction, in/in.

ET(2) = Tensile strain allowable in the 2-direction, in/in.

ET(3) = Positive shear strain allowable, in/in.

Block 7. E1, E2, G, ν_{12} , H, (θ_i , $i = 1, 2, \dots, NPLYS$)

E1 = Modulus in the 0° direction, psi.

E2 = Modulus in the 90° direction, psi.

G = In-plane shear modulus, psi.

ν_{12} = Major Poisson's ratio, dimensionless.

H = Thickness of each ply, in.

θ_i = Orientation of the i^{th} ply, starting with the bottom or inner ply, degrees.

Block 8. (E1) $_i$, (E2) $_i$, G $_i$, (ν_{12}) $_i$, H $_i$, θ_i , [EC(1) $_i$, EC(2) $_i$, EC(3) $_i$, ET(1) $_i$, ET(2) $_i$, ET(3) $_i$], $i = 1, \dots, NPLYS$

E1 $_i$ = Modulus in the 0° direction of the i^{th} ply, psi

E2 $_i$ = Modulus in the 90° direction of the i^{th} ply, psi

G $_i$ = Shear modulus of the i^{th} ply, psi

(ν_{12}) $_i$ = Major Poisson's ratio of the i^{th} ply, dimensionless

H $_i$ = Thickness of the i^{th} ply, in.

θ_i = Orientation of the i^{th} ply, degrees.

(The following allowables are input only if a strength analysis is being performed, IOU ≥ 7 .)

EC(1) $_i$ = Compressive strain allowable in the 1-direction for the i^{th} ply, in/in.

EC(2) $_i$ = Compressive strain allowable in the 2-direction for the i^{th} ply, in./in.

EC(3) $_i$ = Negative shear strain allowable in the 1-2 plane for the i^{th} ply, in/in.

$ET(1)_i$ = Tensile strain allowable in the 1-direction
for the i^{th} ply, in/in.

$ET(2)_i$ = Tensile strain allowable in the 2-direction
for the i^{th} ply, in/in.

$ET(3)_i$ = Positive shear strain allowable in the 1-2
plane for the i^{th} ply, in/in.

Block 9. $E1$, $E2$, G , ν_{12} , H

$E1$ = Inner (outer) facing modulus in the 0°
direction, psi.

$E2$ = Inner (outer) facing modulus in the 90°
direction, psi.

G = Inner (outer) facing shear modulus, psi.

ν_{12} = Inner (outer) facing major Poisson's ratio,
dimensionless.

H = Inner (outer) facing thickness, in.

(If a strength analysis is not being performed, Block 9 is now repeated for the outer facing properties. If a strength analysis is being performed, Blocks 10 and 11 for the inner facing are now input, then Blocks 9, 10 and 11 are input for the outer facing.)

Block 10. $EC(1)$, $EC(2)$, $EC(3)$, $ET(1)$, $ET(2)$, $ET(3)$, MCHK

$EC(1)$ = Inner (outer) facing compressive strain allowable in the 1-direction, in/in.

$EC(2)$ = Inner (outer) facing compressive strain allowable in the 2-direction, in/in.

$EC(3)$ = Inner (outer) facing negative shear strain allowable in the 1-2 plane, in/in.

$ET(1)$ = Inner (outer) facing tensile strain allowable in the 1-direction, in/in.

$ET(2)$ = Inner (outer) facing tensile strain allowable in the 2-direction, in/in.

ET(3) = Inner (outer) facing positive shear strain allowable in the 1-2 plane, in/in.

MCHK = Number of orientations to be checked in the strength analysis of the inner (outer) facing.
 $1 \leq MCHK \leq 10$.

Block 11. ANGCHK_i, i = 1, MCHK

ANGCHK_i = Orientations to be checked in the strength analysis of the inner (outer) facing, degrees.

Block 12. H_c

H_c = Core thickness, in.

Block 13. [YSTRNG], YBAR, ZBAR, AS, XIYYS, XIYZS, XIZZS, ES, GJS, RHOS

YSTRNG = Distance of longitudinal stiffener from y = 0.
For variable stiffener spacing only.

YBAR = Location of stringer centroid in the y-direction with respect to its line of attachment to the shell, in.

ZBAR = Location of stringer centroid in the z-direction with respect to the middle surface of the shell at the line of attachment, in.

AS = Stringer cross-sectional area, in².

XIYYX = Moment of inertia of the stringer area about the mid-surface y- axis at the line of attachment, in⁴.

XIYZS = Product of inertia of the stringer area about the mid-surface y-z axis at the line of attachment, in⁴.

XIZZS = Moment of inertia of the stringer area about the z-axis at the line of attachment, in⁴.

ES = Stringer modulus of elasticity, psi.

GJS = Stringer torsional stiffness, lb-in.².

RHOS = Average density of stringer material,
lb-sec²/in⁴.

Block 13 is repeated 'NSTRNG' times, unless equally-spaced identical stringers were specified.

Block 14. [XRING], XBARR, ZBARR, AR, XIXXR, XIZZR, ER, GJR, RHOR

XRING = Distance of circumferential stiffener from
x = 0. For unequally spaced rings.

XBARR = Location of ring centroid in the x-direction
with respect to its line of attachment to the
shell, in.

ZBARR = Location of ring centroid in the z-direction
with respect to the middle surface of the
shell at the line of attachment, in.

AR = Ring cross-sectional area, in².

XIXXR = Moment of inertia of the ring area about the
mid-surface x-axis at the line of attachment,
in.⁴.

XIXZR = Product of inertia of the ring area about the
mid-surface x-z axis at the line of attach-
ment, in⁴.

XIZZR = Moment of inertia of the ring area about the
z-axis at the line of attachment, in⁴.

ER = Ring modulus of elasticity, psi.

GJR = Ring torsional stiffness, lb-in².

RHOR = Average density of ring material, lb-sec²/in⁴.

Block 14 is repeated 'NRING' time unless equally-spaced identical rings were specified.

Block 15. DENSE

DENSE = Average material density of the shell material,
such that (DENSE) (Vol. of shell) = (Mass of
shell), lb-sec²/in⁴.

Block 16. IX, IY, PMASS

IX = Grid coordinate in x-direction at which lumped mass is located, $1 \leq IX \leq 25$.

IY = Grid coordinate in y-direction at which lumped mass is located, $1 \leq IY \leq 25$.

PMASS = Mass, lb-sec²/in.

Block 16 is repeated 'NLMASS' times.

Block 17. PX(1,1), PY(1,1), PXY(1,1), PX(2,1), PY(2,1), PXY(2,1),
...PX(I,J), PY(I,J), PXY(I,J), I = 1, 2...NPNX, J = 1, 2
...NPNY

The applied in-plane stress resultants are described by the relations

$$N_x(x,y) = \sum_{I=1}^{NPNX} \sum_{J=1}^{NPNY} P_x(I,J) \left(\frac{x}{a}\right)^{I-1} \left(\frac{y}{b}\right)^{J-1}$$

$$N_y(x,y) = \sum_{I=1}^{NPNX} \sum_{J=1}^{NPNY} P_y(I,J) \left(\frac{x}{a}\right)^{I-1} \left(\frac{y}{b}\right)^{J-1}$$

$$N_{xy}(x,y) = \sum_{I=1}^{NPNX} \sum_{J=1}^{NPNY} P_{xy}(I,J) \left(\frac{x}{a}\right)^{I-1} \left(\frac{y}{b}\right)^{J-1}$$

Note: Tension stress resultant are taken as positive.

TORQUE = Torque applied to cylinder, in-lb.

BNDMOM = Bending moment applied to cylinder, in-lb.

Block 19. Q(1,1), Q(2,1), Q(3,1), ...Q(I,J), I = 1, ..., NQTX
J = 1, 2..., NQTY

The distributed lateral load is described by the relation

$$q(x,y) = \sum_{I=1}^{NQTX} \sum_{J=1}^{NQTY} Q(I,J) \left(\frac{x}{a}\right)^{I-1} \left(\frac{y}{b}\right)^{J-1}$$

Note: positive loads are in the positive z-direction.

Block 20. IX, IY, PC

IX = Grid coordinate in x-direction, $1 \leq IX \leq 25$.

IY = Grid coordinate in y-direction, $1 \leq IY \leq 25$.

PC = Concentrated load, lb.

Block 20 is repeated 'NPTLDS' times.

Block 21. IX, IY, ITAG, FC

IX = Grid coordinate in x-direction, $1 \leq IX \leq 25$.

IY = Grid coordinate in the y-direction, $1 \leq IY \leq 25$.

ITAG = +1, if the moment is about the x-axis in a
vector sense (right-hand rule)
= +2, if the moment is about the y-axis.

FC = Moment, in-lb.

Block 21 is repeated 'NPTMOM' times.

Block 22. ITAG, IDIST, PLMOM

ITAG = +1, if the line moment is parallel to the x-axis.
= +2, if the line moment is parallel to the y-axis.

IDIST = Number of grid lines away from the $x = 0$ or
 $y = 0$ axis. $1 \leq IDIST \leq 25$.

PLMOM = Line moment per unit of length, in-lb/in.

Block 22 is repeated 'NLNMOM' times.

Block 23. IX, IY, PKC

IX = Grid coordinate in x-direction. $1 \leq IX \leq 25$.

IY = Grid coordinate in y-direction. $1 \leq IY \leq 25$.

PKC = Spring constant, lb/in.

Block 23 is repeated 'NPTSUP' times.

Block 24. ITAG, IDIST, PLINE

ITAG = +1, if the line spring is parallel to the x-axis.
 = +2, if the line spring is parallel to the y-axis.

IDIST = Number of grid lines away from the x=0 or y=0 axis. $1 \leq \text{IDIST} \leq 25$.

PLINE = Spring constant per unit length, lb/in².

Block 24 is repeated 'NLNSPR' times.

Block 25. XP(I), YP(I), I = 1, IFLEX

XP(I) = X-coordinate (in %) of Ith flexibility matrix control point.

YP(I) = Y-coordinate (in %) of Ith flexibility matrix control point.

OUTPUT DATA DESCRIPTION

Most of the output is labeled with the exception of the 'CONTRIBUTIONS OF THE SERIES TERMS'. These are the solution vectors used for the modal analysis. They are printed in the following order:

$a_{111}, a_{112}, a_{113}, \dots, a_{11(\text{NTY})}, a_{121}, a_{122}, \dots, a_{12(\text{NTY})},$
 $\dots, a_{1(\text{NTX})1}, a_{1(\text{NTX})2}, \dots, a_{1(\text{NTX})\text{NTY}}, a_{211}, a_{212},$
 $\dots, a_{2(\text{NTX})(\text{NTY})}, a_{311}, a_{312}, \dots, a_{3(\text{NTX})(\text{NTY})}$

where

$$u = \sum_{m=M_i}^{M_f} \sum_{n=N_i}^{N_f} a_{1mn} X_{1m} Y_{1n}$$

$$v = \sum_{m=M_i}^{M_f} \sum_{n=N_i}^{N_f} a_{2mn} X_{2m} Y_{2n}$$

$$w = \sum_{m=M_i}^{M_f} \sum_{n=N_i}^{N_f} a_{3mn} X_{3m} Y_{3n}$$

$$\begin{aligned}
M_i &= ITX. \\
M_f &= ITX + NTX - 1. \\
N_i &= ITY. \\
N_f &= ITY + NTY - 1.
\end{aligned}$$

For a buckling solution only the a_{3mn} are printed.

RESTRICTIONS

The ranges of the input parameters are described under INPUT DATA.

The main restriction is to keep in mind the assumptions of the analysis, particularly the small-deflection assumption. If the deflections found in a lateral loads problem are greater than the panel thickness, the results are questionable.

If a solution mode shape contains large contributions from the highest modal shape input, the solution is questionable, and the analysis should be rerun using the highest mode shape input as the initial term in the new analysis. Since the high-order modes are not sensitive to boundary conditions, the restriction to simply-supported or full cylinder boundary conditions will not make much difference in the results.

ESTIMATED RUNNING TIME

The run times may vary considerably depending solely on the size of the matrix to be inverted and solved for eigenvalues. A meaningful buckling problem may be solved in 10 to 20 seconds, while a large vibration problem with many mode shapes desired may run up to 10 minutes. For the static deflection and buckling problem, an estimate of the run time can be obtained as

$$t = 9.4 \quad 0.0666 (NTX*NTY) \quad \text{sec.}$$

The vibration problems normally run up to twice as long as the corresponding buckling problems, and can run longer when many modes are desired.

A P P E N D I X I I I

S A M P L E P R O B L E M S

6 59A
 6 ++1 +3+3 +5+5 +1+1 ++2+6 ++1+++++1+1+++++
 6 +12 +8 +12 +.0010
 6+21000000+1700000+650000+.21+.0070+-60+60+60-60+
 6 +1++

004602P540001
 004602P540002
 004602P540003
 004602P540004
 004602P540005

59A

THE BOUNDARY CONDITIONS AT X=0 AND X=A ARE
CLAMPED, CLAMPED

THE BOUNDARY CONDITIONS AT Y=0 AND Y=B ARE
CLAMPED, CLAMPED

THERE ARE 5 MODES IN THE X DIRECTION, STARTING WITH M = 1 :
THERE ARE 5 MODES IN THE Y DIRECTION, STARTING WITH N = 1 :

THE STIFFNESS MATRIX SIZE IS 75 BY 75

A SOLUTION UNDER LATERAL LOADS WILL BE SOUGHT

A = 12.00000

B = 8.00000

R = 12.00000

MU = 0.0

FOR THE 6 PLY LAMINATE

E1 = 0.210000E 08

E2 = 0.170000E 07

G = 0.650000E 06

NU12 = 0.2100

H(1) = 0.0070

T = 0.0420

THE ORIENTATIONS ARE
0.0

-60.0000

60.0000

60.0000

-60.0000

0.0

GENERAL DYNAMICS CONVAIR AEROSPACE DIVISION FORT WORTH OPERATION
 37C PROCEDURE SS8 PRCHLEM 004602-54 C4/16/73 PAGE 0002

THE CONSTITUTIVE MATRIX IS

| | | | | | |
|---------------|---------------|---------------|----------------|----------------|----------------|
| 0.3762170E 06 | 0.1172375E 06 | 0.0 | 0.3906250E-02 | 0.2136230E-03 | 0.0 |
| 0.1172375E 06 | 0.3762169E 06 | 0.0 | 0.2136230E-03 | 0.0 | 0.0 |
| 0.0 | 0.0 | 0.1294858E 06 | 0.0 | 0.0 | 0.1678467E-03 |
| 0.3906250E-02 | 0.2136230E-03 | 0.0 | 0.9686734E 02 | 0.8888407E 01 | -0.2862569E 01 |
| 0.2136230E-03 | 0.0 | 0.0 | 0.8888407E 01 | 0.3043127E 02 | -0.8644495E 01 |
| 0.0 | 0.0 | 0.1678467E-03 | -0.2862569E 01 | -0.8644495E 01 | 0.1068948E 02 |

THE LAMINATE PROPERTIES ARE

EX = 0.808769E 07 EY = 0.808769E 07 G = 0.308309E 07 NUXY = 0.3116 NUXX = 0.3116

Q(I,J) FOLLOWS
 1.0000E 00

GENERAL DYNAMICS
370 PROCEDURE SS8

CCNAVIR AEROSPACE DIVISION
PROBLEM 004602-54

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THE CONTRIBUTIONS OF THE SERIES TERMS TO REFLECTION FOLLOW

| | | | | | | | | | |
|-------------|-------------|-------------|-------------|------------|-------------|-------------|-------------|-------------|-------------|
| 0.5184E-05 | -0.3113E-16 | 0.3784E-06 | 0.4528E-16 | 0.1862E-06 | 0.1995E-16 | 0.9983E-09 | -0.2213E-17 | -0.1041E-08 | -0.3966E-15 |
| 0.1313E-06 | -0.3206E-17 | 0.3767E-07 | 0.2823E-17 | 0.3791E-07 | 0.5546E-17 | -0.8079E-09 | 0.6264E-18 | 0.9691E-09 | 0.1576E-17 |
| 0.3827E-07 | -0.1220E-17 | 0.1065E-07 | -0.8611E-18 | 0.8614E-08 | 0.4368E-05 | 0.4131E-16 | 0.1860E-06 | -0.4679E-16 | -0.1867E-07 |
| -0.6900E-15 | -0.4840E-08 | -0.4833E-17 | 0.8495E-09 | 0.1098E-17 | 0.1061E-05 | 0.1504E-17 | 0.1792E-06 | -0.6508E-18 | 0.6608E-08 |
| 0.2420E-16 | 0.6866E-08 | 0.4198E-17 | -0.4262E-08 | 0.3072E-19 | 0.4348E-06 | 0.4974E-17 | 0.8720E-07 | 0.5054E-17 | 0.1355E-07 |
| 0.3430E-03 | 0.3016E-14 | 0.7821E-04 | -0.1067E-13 | 0.8165E-05 | -0.5216E-14 | -0.5493E-06 | -0.1595E-14 | 0.2288E-06 | 0.3261E-15 |
| 0.1310E-03 | -0.6141E-15 | 0.5687E-04 | 0.9607E-15 | 0.1286E-04 | 0.4071E-14 | 0.4955E-06 | 0.1628E-14 | -0.1509E-05 | 0.8037E-15 |
| 0.6974E-04 | -0.3629E-15 | 0.3075E-04 | 0.1811E-14 | 0.1175E-04 | | | | | |

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[illegible]

GENERAL DYNAMICS
37C PROCEDURE S38

CONVAIR AEROSPACE DIVISION
PROBLEM 004002-54

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THE EXECUTION TIME FOR THIS PROBLEM WAS 0 MINUTES, 30 SECONDS.

6 SAMPLE PROBLEM - SHEAR BUCKLING
 6 ++2+ +3+2 +5+10 +1+1 ++2+8 ++1 +1+1+1 ++++++
 6 +9 +16.45 +12
 6 +21000000 +1700000 +650000 +.21 +.007
 6 +45-45+45-45-45+45-45+45
 6 ++1

004602P010001
 004602P010002
 004602P010003
 004602P010004
 004602P010005
 004602P010006

SAMPLE PROBLEM - SHEAR BUCKLING

THE BOUNDARY CONDITIONS AT X=0 AND X=A ARE
 CLAMPED, CLAMPED

THE BOUNDARY CONDITIONS AT Y=0 AND Y=B ARE
 SIMPLE, SIMPLE

THERE ARE 5 MODES IN THE X DIRECTION, STARTING WITH M = 1 .
 THERE ARE 10 MODES IN THE Y DIRECTION, STARTING WITH N = 1 .

THE STIFFNESS MATRIX SIZE IS 150 BY 150

A STABILITY SOLUTION WILL BE SOUGHT

A = 9.00000

B = 16.45000

R = 12.00000

MU = 0.0

FOR THE 8 PLY LAMINATE

E1 = 0.210000E 08

E2 = 0.170000E 07

G = 0.650000E 06

NU12 = 0.2100

H(1) = 0.0070

T = 0.0560

THE ORIENTATIONS ARE
 45.0000

-45.0000

45.0000

-45.0000

-45.0000

45.0000

-45.0000

GENERAL DYNAMICS
370 PROCEDURE SS8

CONVAIR AEROSPACE DIVISION
PROBLEM 004602-01

FORT WORTH OPERATION
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45.0000

GENERAL DYNAMICS CONVAIR AEROSPACE DIVISION FORT WORTH OPERATION
370 PROCEDURE 558 PROBLEM 004602-01 05/04/73 PAGE 0003

THE CONSTITUTIVE MATRIX IS

| | | | | | |
|---------------|---------------|---------------|---------------|---------------|---------------|
| 0.3653700E 06 | 0.2925696E 06 | 0.0 | 0.3662109E-02 | 0.1220703E-03 | 0.1220703E-03 |
| 0.2925696E 06 | 0.3653695E 06 | 0.0 | 0.1220703E-03 | 0.2929688E-02 | 0.1220703E-03 |
| 0.0 | 0.0 | 0.3089061E 06 | 0.1220703E-03 | 0.1220703E-03 | 0.7324219E-03 |
| 0.3662109E-02 | 0.1220703E-03 | 0.1220703E-03 | 0.9548331E 02 | 0.7645819E 02 | 0.2657442E 02 |
| 0.1220703E-03 | 0.2929688E-02 | 0.1220703E-03 | 0.7645819E 02 | 0.9548315E 02 | 0.2657440E 02 |
| 0.1220703E-03 | 0.1220703E-03 | 0.7324219E-03 | 0.2657442E 02 | 0.2657440E 02 | 0.8072745E 02 |

THE LAMINATE PROPERTIES ARE

EX = 0.234098E 07 EY = 0.234098E 07 G = 0.551618E 07 NUXY = 0.8008 NUXX = 0.8007

PX(I,J) FOLLOWS
0.0

PY(I,J) FOLLOWS
0.0

PXY(I,J) FOLLOWS
1.0000E 00

THE BUCKLING EIGENVALUE IS 0.5006819E 03 FOR M = 1, N = 6.

THE CONTRIBUTIONS OF THE SERIES TERMS FOR W FOLLOW

| | | | | | | | | | |
|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
| -0.2243E-11 | 0.7644E-02 | -0.1333E-10 | 0.4221E-01 | -0.2644E-09 | 0.1142E 01 | 0.6323E-09 | -0.6329E 00 | -0.1261E-09 | -0.1098E-01 |
| -0.8917E-02 | -0.5158E-11 | -0.3619E-01 | -0.4761E-11 | -0.2724E 00 | -0.4363E-09 | 0.1000E 01 | 0.4095E-09 | -0.2227E 00 | -0.1120E-10 |
| 0.3574E-11 | -0.1415E-01 | 0.7597E-11 | -0.1920E-01 | 0.2547E-10 | -0.2264E 00 | -0.2083E-09 | 0.3338E 00 | 0.9032E-10 | -0.1029E-01 |
| 0.1386E-02 | 0.3442E-11 | -0.3647E-02 | 0.9592E-11 | -0.4007E-01 | -0.4753E-10 | 0.1214E-01 | 0.2539E-11 | 0.4119E-01 | 0.8886E-11 |
| 0.1435E-11 | -0.5456E-03 | 0.5684E-11 | 0.3906E-02 | 0.3032E-10 | -0.4466E-01 | -0.8372E-10 | 0.4226E-01 | 0.1792E-10 | 0.8568E-02 |

FORT WORTH OPERATION
05/04/73 PAGE 0004

[illegible]

GENERAL DYNAMICS
370 PROCEDURE SS8

CONVAIR AEROSPACE DIVISION
PROBLEM 004602-01

FORT WORTH OPERATION
05/04/73 PAGE 0005

THE BUCKLING EIGENVALUE IS -0.7427390E 03 FOR M = 1, N = 6.

THE CONTRIBUTIONS OF THE SERIES TERMS FOR W FOLLOW

| | | | | | | | | | |
|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
| 0.3631E-11 | -0.2483E-02 | 0.2058E-10 | -0.6968E-01 | 0.5375E-09 | 0.1000E 01 | -0.4853E-09 | -0.2751E 00 | 0.1554E-11 | -0.3611E-01 |
| 0.9910E-02 | 0.9287E-11 | 0.3884E-01 | 0.6842E-10 | 0.3470E 00 | -0.4849E-09 | -0.6145E 00 | 0.1527E-09 | 0.3848E-02 | 0.2147E-10 |
| -0.5746E-11 | 0.1553E-02 | -0.1276E-10 | 0.2179E-02 | -0.4942E-10 | -0.1588E 00 | 0.1306E-09 | 0.1111E 00 | -0.3316E-11 | 0.2021E-01 |
| -0.1692E-02 | 0.1568E-11 | -0.6809E-03 | 0.1755E-10 | 0.4223E-01 | -0.4988E-10 | -0.3605E-01 | 0.4644E-11 | -0.6943E-02 | -0.1012E-13 |
| -0.1235E-11 | 0.1412E-02 | -0.3039E-11 | 0.4844E-02 | -0.2492E-10 | -0.2717E-01 | 0.4598E-10 | 0.1869E-01 | 0.5196E-12 | 0.4790E-02 |

FORT WORTH OPERATION
05/04/73 PAGE 0006

[illegible]

GENERAL DYNAMICS
370 PROCEDURE SS8

CONVAIR AEROSPACE DIVISION
PROBLEM 004602-01

FORT WORTH OPERATION
05/04/73 PAGE 0007

THE EXECUTION TIME FOR THIS PROBLEM WAS 2 MINUTES, 48 SECONDS.

6 SAMPLE PROBLEM - PANEL VIBRATION
 6 +1+ +4+2 +3+3 +1+1 +3 +2+2++1 ++++++
 6 +6 +4 +20
 6 +30000000 +2700000 +650000 +.21 +.0053 +45-45
 6 +.00018

004602P020001
 004602P020002
 004602P020003
 004602P020004
 004602P020005

SAMPLE PROBLEM - PANEL VIBRATION

THE BOUNDARY CONDITIONS AT $X=0$ AND $X=A$ ARE
CLAMPED, FREE

THE BOUNDARY CONDITIONS AT $Y=0$ AND $Y=B$ ARE
SIMPLE, SIMPLE

THERE ARE 3 MODES IN THE X DIRECTION, STARTING WITH $M = 1$.
THERE ARE 3 MODES IN THE Y DIRECTION, STARTING WITH $N = 1$.

THE STIFFNESS MATRIX SIZE IS 27 BY 27

A DYNAMIC SOLUTION WILL BE SOUGHT

A = 6.00000

B = 4.00000

R = 20.00000

MU = 0.0

FOR THE 2 PLY LAMINATE

E1 = 0.300000E 08

E2 = 0.270000E 07

G = 0.650000E 06

NU12 = 0.2100

H(1) = 0.0053

T = 0.0106

THE ORIENTATIONS ARE
45.0000

-45.0000

GENERAL DYNAMICS
370 PROCEDURE SS8

CONVAIR AEROSPACE DIVISION
PROBLEM 004602-02

FORT WORTH OPERATION
05/04/73 PAGE 0002

THE CONSTITUTIVE MATRIX IS

| | | | | | |
|----------------|----------------|----------------|----------------|----------------|----------------|
| 0.9690731E 05 | 0.8312731E 05 | 0.0 | 0.0 | 0.0 | -0.1924780E 03 |
| 0.8312731E 05 | 0.9690725E 05 | 0.0 | 0.0 | 0.0 | -0.1924779E 03 |
| 0.0 | 0.0 | 0.8398313E 05 | -0.1924780E 03 | -0.1924779E 03 | 0.0 |
| 0.0 | 0.0 | -0.1924780E 03 | 0.9073753E 00 | 0.7783483E 00 | 0.0 |
| 0.0 | 0.0 | -0.1924779E 03 | 0.7783483E 00 | 0.9073747E 00 | 0.0 |
| -0.1924780E 03 | -0.1924779E 03 | 0.0 | 0.0 | 0.0 | 0.7863617E 00 |

THE LAMINATE PROPERTIES ARE

EX = 0.241514E 07 EY = 0.241514E 07 G = 0.792294E 07 NUXY = 0.8578 NUYX = 0.8578

THE MATERIAL DENSITY = 0.18000000E-03 LB.-SEC.**2/IN.**4

| FREQUENCY | M | N |
|-------------|---|---|
| 0.17837E 03 | 1 | 1 |
| 0.22114E 03 | 1 | 2 |
| 0.44064E 03 | 2 | 2 |
| 0.53527E 03 | 1 | 3 |
| 0.69488E 03 | 2 | 3 |
| 0.96692E 03 | 2 | 1 |
| 0.99399E 03 | 2 | 1 |
| 0.10902E 04 | 3 | 3 |
| 0.14863E 04 | 3 | 1 |
| 0.13607E 05 | 2 | 1 |
| 0.18098E 05 | 1 | 1 |
| 0.25587E 05 | 3 | 2 |
| 0.30574E 05 | 1 | 1 |
| 0.37216E 05 | 2 | 2 |
| 0.39052E 05 | 1 | 1 |
| 0.48045E 05 | 3 | 3 |
| 0.51674E 05 | 1 | 2 |
| 0.57091E 05 | 2 | 1 |
| 0.62332E 05 | 2 | 3 |
| 0.63678E 05 | 1 | 2 |
| 0.71649E 05 | 3 | 1 |
| 0.77191E 05 | 1 | 3 |
| 0.80854E 05 | 2 | 2 |
| 0.90266E 05 | 1 | 3 |
| 0.96942E 05 | 3 | 2 |

GENERAL DYNAMICS
370 PROCEDURE SS8

CONVAIR AEROSPACE DIVISION
PROBLEM 004602-02

FORT WORTH OPERATION
05/04/73 PAGE 0004

0.10690E 06 2 3

0.12326E 06 3 3

GENERAL DYNAMICS
370 PROCEDURE SS8

CONVAIR AEROSPACE DIVISION
PROBLEM 004602-02

FORT WORTH OPERATION
05/04/73 PAGE 0005

THE FREQUENCY IS 0.1783669E 03 CPS. FOR M = 1, N = 1.

THE CONTRIBUTIONS OF THE SERIES TERMS FOLLOW

| | | | | | | | | | |
|-------------|-------------|-------------|------------|-------------|-------------|-------------|------------|-------------|------------|
| -0.1106E-01 | -0.8295E-03 | -0.4571E-04 | 0.9215E-03 | -0.1925E-04 | 0.5167E-05 | 0.1470E-03 | 0.2947E-05 | -0.2778E-05 | 0.1866E-01 |
| 0.1068E-02 | -0.5834E-04 | -0.1127E-02 | 0.1236E-03 | 0.1372E-04 | -0.1871E-03 | -0.6356E-06 | 0.3680E-05 | 0.9776E 00 | 0.1939E 00 |
| -0.2981E-01 | 0.4485E-01 | 0.2445E-01 | 0.3505E-02 | 0.5183E-01 | 0.1346E-02 | -0.1478E-03 | | | |

FORT WORTH OPERATION
05/04/73 PAGE 0006

| | | | | | | | | | | | | | | | | | | | |
|---|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 10 | 20 | 29 | 37 | 45 | 51 | 56 | 59 | 61 | 61 | 60 | 58 | 55 | 51 | 46 | 41 | 36 | 30 | 25 |
| 0 | 38 | 75 | 109 | 141 | 169 | 192 | 210 | 222 | 229 | 231 | 227 | 219 | 207 | 192 | 174 | 155 | 135 | 114 | 94 |
| 0 | 79 | 157 | 230 | 297 | 355 | 403 | 441 | 467 | 481 | 484 | 476 | 459 | 433 | 401 | 363 | 322 | 280 | 237 | 194 |
| 0 | 132 | 260 | 381 | 490 | 587 | 666 | 728 | 771 | 794 | 799 | 785 | 756 | 712 | 658 | 595 | 527 | 457 | 385 | 315 |
| 0 | 191 | 376 | 551 | 710 | 849 | 964 | 1054 | 1115 | 1148 | 1153 | 1133 | 1089 | 1025 | 945 | 854 | 754 | 651 | 548 | 447 |
| 0 | 254 | 500 | 733 | 944 | 1129 | 1282 | 1400 | 1481 | 1525 | 1531 | 1502 | 1442 | 1355 | 1247 | 1124 | 991 | 853 | 716 | 582 |
| 0 | 318 | 628 | 919 | 1184 | 1416 | 1608 | 1756 | 1857 | 1910 | 1916 | 1878 | 1801 | 1690 | 1552 | 1395 | 1226 | 1053 | 880 | 713 |
| 0 | 383 | 755 | 1105 | 1424 | 1702 | 1933 | 2110 | 2231 | 2294 | 2300 | 2252 | 2157 | 2020 | 1852 | 1660 | 1455 | 1245 | 1037 | 837 |
| 0 | 446 | 879 | 1287 | 1658 | 1983 | 2252 | 2458 | 2599 | 2671 | 2676 | 2618 | 2504 | 2342 | 2143 | 1916 | 1675 | 1428 | 1185 | 953 |
| 0 | 507 | 1000 | 1464 | 1887 | 2256 | 2563 | 2798 | 2958 | 3039 | 3044 | 2976 | 2843 | 2656 | 2425 | 2164 | 1886 | 1603 | 1325 | 1061 |
| 0 | 566 | 1117 | 1636 | 2110 | 2524 | 2867 | 3131 | 3310 | 3401 | 3406 | 3329 | 3178 | 2965 | 2703 | 2407 | 2092 | 1773 | 1461 | 1165 |
| 0 | 625 | 1233 | 1806 | 2329 | 2788 | 3169 | 3462 | 3661 | 3763 | 3769 | 3682 | 3514 | 3276 | 2983 | 2652 | 2300 | 1944 | 1597 | 1270 |
| 0 | 683 | 1348 | 1976 | 2550 | 3053 | 3473 | 3797 | 4018 | 4132 | 4139 | 4046 | 3860 | 3597 | 3273 | 2907 | 2518 | 2124 | 1741 | 1381 |
| 0 | 743 | 1466 | 2150 | 2775 | 3326 | 3786 | 4143 | 4387 | 4515 | 4527 | 4427 | 4226 | 3939 | 3584 | 3182 | 2754 | 2321 | 1900 | 1504 |
| 0 | 804 | 1588 | 2330 | 3010 | 3610 | 4114 | 4506 | 4777 | 4922 | 4939 | 4835 | 4619 | 4308 | 3922 | 3483 | 3015 | 2540 | 2078 | 1645 |
| 0 | 869 | 1716 | 2520 | 3258 | 3911 | 4461 | 4893 | 5194 | 5358 | 5383 | 5276 | 5046 | 4712 | 4294 | 3817 | 3306 | 2788 | 2282 | 1807 |
| 0 | 938 | 1852 | 2721 | 3521 | 4232 | 4832 | 5306 | 5640 | 5826 | 5863 | 5754 | 5512 | 5155 | 4704 | 4187 | 3633 | 3067 | 2514 | 1993 |
| 0 | 1010 | 1997 | 2935 | 3801 | 4573 | 5228 | 5748 | 6118 | 6330 | 6379 | 6272 | 6018 | 5637 | 5153 | 4595 | 3994 | 3378 | 2774 | 2203 |
| 0 | 1087 | 2149 | 3161 | 4097 | 4933 | 5646 | 6216 | 6626 | 6866 | 6931 | 6825 | 6560 | 6156 | 5638 | 5038 | 4388 | 3719 | 3062 | 2437 |
| 0 | 1167 | 2309 | 3398 | 4407 | 5312 | 6086 | 6708 | 7161 | 7431 | 7513 | 7410 | 7135 | 6708 | 6156 | 5511 | 4810 | 4087 | 3372 | 2690 |
| 0 | 1251 | 2474 | 3643 | 4728 | 5703 | 6542 | 7219 | 7716 | 8017 | 8118 | 8020 | 7735 | 7284 | 6697 | 6008 | 5254 | 4474 | 3700 | 2958 |
| 0 | 1336 | 2643 | 3893 | 5057 | 6104 | 7008 | 7742 | 8284 | 8619 | 8739 | 8645 | 8351 | 7877 | 7254 | 6520 | 5713 | 4874 | 4039 | 3237 |
| 0 | 1422 | 2814 | 4147 | 5389 | 6510 | 7481 | 8272 | 8860 | 9228 | 9368 | 9280 | 8976 | 8478 | | | | | | |

GENERAL DYNAMICS
370 PROCEDURE SS8

CUNVAIR AEROSPACE DIVISION
PROBLEM 004602-02

FORT WORTH OPERATION
05/04/73 PAGE 0007

THE FREQUENCY IS 0.221141E 03 CPS. FOR M = 1, N = 2.

THE CONTRIBUTIONS OF THE SERIES TERMS FOLLOW

| | | | | | | | | | |
|------------|-------------|-------------|-------------|-------------|------------|-------------|------------|-------------|-------------|
| 0.4073E-02 | -0.3105E-02 | -0.4223E-03 | -0.3826E-03 | -0.9828E-05 | 0.6660E-04 | -0.3544E-04 | 0.9751E-04 | -0.2021E-04 | -0.3748E-02 |
| 0.4950E-02 | 0.7037E-04 | -0.1562E-03 | 0.1002E-03 | 0.2738E-04 | 0.1240E-03 | -0.1352E-03 | 0.1602E-04 | -0.1920E 00 | 0.9796E 00 |
| 0.8096E-02 | -0.3797E-01 | 0.4220E-01 | 0.3574E-02 | -0.1021E-01 | 0.1279E-02 | 0.8947E-03 | | | |

GENERAL DYNAMICS
370 PROCEDURE 558

CONVAIR AEROSPACE DIVISION
PROBLEM 004602-02

FORT WORTH OPERATION
05/04/73 PAGE 0009

THE FREQUENCY IS 0.4406414E 03 CPS. FOR M = 2, N = 2.

THE CONTRIBUTIONS OF THE SERIES TERMS FOLLOW

| | | | | | | | | | |
|-------------|-------------|-------------|-------------|-------------|-------------|-------------|------------|-------------|-------------|
| 0.2342E-02 | 0.6560E-03 | -0.4196E-03 | -0.1309E-04 | -0.2959E-02 | -0.2190E-03 | -0.7851E-04 | 0.3729E-03 | 0.4559E-04 | 0.5082E-03 |
| 0.4210E-03 | -0.2247E-03 | 0.9733E-03 | 0.5467E-02 | 0.1417E-03 | -0.6676E-03 | -0.2815E-03 | 0.1048E-03 | -0.1788E-01 | -0.4466E-01 |
| -0.3510E-01 | 0.5143E-01 | 0.9952E 00 | 0.2964E-01 | -0.3236E-01 | 0.3157E-01 | 0.2215E-01 | | | |

FORT WORTH OPERATION
05/04/73 PAGE 0010

[illegible]

GENERAL DYNAMICS
370 PROCEDURE SS8

CONVAIR AEROSPACE DIVISION
PROBLEM 004602-02

FORT WORTH OPERATION
05/04/73 PAGE 0011

THE EXECUTION TIME FOR THIS PROBLEM WAS 0 MINUTES, 15 SECONDS.

A P P E N D I X I V

P R O G R A M L I S T I N G S

| | | |
|---|--|---------|
| C | CONTROL PROGRAM FOR THE ANALYSIS OF ANISOTROPIC CURVED PANELS. | SS8A000 |
| C | | SS8A001 |
| | CALL GSTART ('SS8',IDIOT) | SS8A002 |
| 1 | CALL READ | SS8A003 |
| | CALL TABLE | SS8A004 |
| | CALL ASEMBL | SS8A005 |
| | CALL SOLVE | SS8A006 |
| | CALL PRINT | SS8A007 |
| | GO TO 1 | SS8A008 |
| | END | SS8A009 |

CC = 00010

```

SUBROUTINE READ
C
C ** THIS SUBROUTINE READS ALL THE NECESSARY INPUT DATA, MAKES DATA
C ** CHECKS, AND WRITES PRELIMINARY DATA.
C
DIMENSION YSTRNG(100), YBARS(100), ZBARS(100), AS(100), SS8B005
1 XIYYS(100), XIYZS(100), XIZZS(100), ES(100), SS8B006
2 GJS(100), RHOS(100), PAXS(100), SS8B007
3 XRINGS(50), XBARR(50), ZBARR(50), AR(50), SS8B008
4 XIXXR(50), XIXZR(50), XIZZR(50), ER(50), SS8B009
5 GJR(50), RHOR(50), PAXR(50), SS8B010
8 PMASS(50), IPWW(50), IPWY(50), SS8B011
9 PX(10,10), PY(10,10), PXY(10,10), SS8B012
C PC(50), IPXX(50), IPYY(50), SS8B013
D FC(50), IFXX(50), IFYY(50), SS8B014
E ITAGCM(50), Q(10,10), SS8B015
F PLMOM(50), ITAGLM(50), IDISLM(50), SS8B016
G PKC(50), IGSPRX(50), IGSPRY(50), SS8B017
H PLINE(50), IDISLS(50), ITAGLS(50), SS8B018
DIMENSION ITIME(12), TIME(50), SS8B019
DIMENSION AMAT(3,3), BMAT(3,3), DMAT(3,3), H(40), SS8B020
1 THETA(40), E1(40), E2(40), G(40), SS8B021
2 XNU12(40), SS8B022
DIMENSION EC(3,40), ET(3,40), ANGCK(3,10), MCHK(3), SS8B023
DIMENSION V(2,10), PRTNX(5,5), PRTNY(5,5), SS8B024
1 PRTNXY(5,5), PRTQ(5,5), SS8B025
DIMENSION AI(3,3), A(3,3), SS8B026
COMMON U(50,50), SS8B027
COMMON / CHECKS / IERROR, SS8B028
COMMON / CNTROL / IFLAGD, IFLAGB, IFLAGW, IBCX, IBCY, SS8B029
1 IMATL, IEDGE, IREACT, IOUT, IPRTN, SS8B030
2 IPRTQ, IELAST, INTPT, IKDF, IFLEX, SS8B031
COMMON / NUMBER / NPLYS, NTUX, NTVX, NTWX, NTUY, SS8B032
1 NTVY, NTWY, NMODES, NSTRNG, NRING, SS8B033
2 NPNX, NPNY, NQTX, NQTY, NPTLDS, NPTMOM, SS8B034
3 NLNMOM, NLMASS, NPTSUP, NLNSPR, SS8B035
4 MATSIZ, MUVSIZ, MWSIZ, ITX, ITY, SS8B036
COMMON / GEOM / AA, BB, RR, ALFAX, ALFAY, SS8B037
1 BETAX, BETAY, MU, SS8B038
COMMON / $TIME / TIME, ITIME, SS8B039
COMMON / ABD / AMAT, BMAT, DMAT, RHAB, THETA, SS8B040
1 H, E1, E2, G, XNU12, SS8B041
2 EC, ET, ANGCK, MCHK, SS8B042
COMMON / PARAM / YBARS, ZBARS, AS, XIYYS, XIYZS, SS8B043
1 XIZZS, ES, GJS, RHOS, PAXS, SS8B044
3 XBARR, ZBARR, AR, XIXXR, XIXZR, SS8B045
4 XIZZR, ER, GJR, RHOR, PAXR, SS8B046
6 PMASS, IPWW, IPWY, PX, PY, SS8B047
7 PXY, PC, IPXX, IPYY, FC, SS8B048
8 IFXX, IFYY, ITAGCM, Q, PLMOM, SS8B049
9 ITAGLM, IDISLM, PKC, IGSPRX, IGSPRY, SS8B050
A PLINE, IDISLS, ITAGLS, SS8B051
COMMON / STFVAL / ESV(10,100), ESX(10,100), ESDW(10,100), SS8B052
1 ERU(10,50), ERW(10,50), ERDW(10,50), SS8B053
2 YSTRNG, XRINGS, SS8B054
COMMON / FLEXBL / XP(50), YP(50), SS8B055

```

| | | |
|------|--|---------|
| | EQUIVALENCE (U(1),PRTNX(1)), (U(26),PRTNY(1)), (U(51), | SS8B056 |
| 1 | PRTNXY(1)), (U(76),PRTQ(1)), (U(101),V(1)) | SS8B057 |
| C | | SS8B058 |
| | DATA XDIR / 'X' /, YDIR / 'Y' / | SS8B059 |
| | DATA KIN / 'INN' /, KOUT / 'OUT' / | SS8B060 |
| | REAL MU | SS8B061 |
| C | | SS8B062 |
| 1 | CALL PROB | SS8B063 |
| | CALL STATUS (ITIME) | SS8B064 |
| | TIME(1) = .01*ITIME(8) | SS8B065 |
| C ** | READ AND WRITE TITLE | SS8B066 |
| | READ (5,2) | SS8B067 |
| 2 | FORMAT (1X,65H | SS8B068 |
| 1 |) | SS8B069 |
| | WRITE (6,2) | SS8B070 |
| | CALL FREEFD | SS8B071 |
| 5 | FORMAT (1X) | SS8B072 |
| | READ (5,5) XFLAGD, XFLAGB, XFLAGW, XBCX , XBCY , XTUX , XTUY , | SS8B073 |
| 1 | XTX , XTY , XMODES, XMATL , XPLYS , | SS8B074 |
| 2 | XREACT, XOUT , XEDGE , XPNX , XPNY , XPRTN , | SS8B075 |
| 3 | XQTX , XQTY , XPRTQ , XSTRNG, XRING , XLMASS, XPTLDS, | SS8B076 |
| 4 | XPTMOM, XLNMOM, XPTSUP, XLNSPR, XNTPRT, XFLEX | SS8B077 |
| C ** | CONVERT FROM REAL TO INTEGER | SS8B078 |
| | INTPRT = XNTPRT + .1 | SS8B079 |
| | IFLAGD = XFLAGD + .1 | SS8B080 |
| | IFLAGB = XFLAGB + .1 | SS8B081 |
| | IKDF = 0 | SS8B082 |
| | IF (IFLAGB - 2) 4,4,3 | SS8B083 |
| 3 | IKDF = 1 | SS8B084 |
| | IFLAGB = IFLAGB - 2 | SS8B085 |
| 4 | CONTINUE | SS8B086 |
| | IFLAGW = XFLAGW + .1 | SS8B087 |
| | IBCX = XBCX + .1 | SS8B088 |
| | IBCY = XBCY + .1 | SS8B089 |
| | IMATL = XMATL + .1 | SS8B090 |
| | IEDGE = XEDGE + .1 | SS8B091 |
| | IREACT = XREACT + .1 | SS8B092 |
| | IOUT = XOUT + .1 | SS8B093 |
| | IPRTN = XPRTN + .1 | SS8B094 |
| | IPRTQ = XPRTQ + .1 | SS8B095 |
| | NPLYS = XPLYS + .1 | SS8B096 |
| | NTUX = XTUX + .1 | SS8B097 |
| | NTVX = NTUX | SS8B098 |
| | NTWX = NTUX | SS8B099 |
| | NTUY = XTUY + .1 | SS8B100 |
| | NTVY = NTUY | SS8B101 |
| | NTWY = NTUY | SS8B102 |
| | ITX = XTX + .1 | SS8B103 |
| | ITY = XTY + .1 | SS8B104 |
| | NMODES = XMODES + .1 | SS8B105 |
| | IEQS = 0 | SS8B106 |
| | IEQR = 0 | SS8B107 |
| | IF (XSTRNG .LT. 0.) IEQS = 1 | SS8B108 |
| | XSTRNG = ABS (XSTRNG) | SS8B109 |
| | IF (XRING .LT. 0.) IEQR = 1 | SS8B110 |
| | XRING = ABS (XRING) | SS8B111 |

| | |
|--|---------|
| NSTRNG = XSTRNG + .1 | SS8B112 |
| NRING = XRING + .1 | SS8B113 |
| NPNX = XPNX + .1 | SS8B114 |
| NPNY = XPNY + .1 | SS8B115 |
| NQTX = XQTX + .1 | SS8B116 |
| NQTY = XQTY + .1 | SS8B117 |
| NPTLDS = XPTLDS + .1 | SS8B118 |
| NPTMOM = XPTMOM + .1 | SS8B119 |
| NLNMOM = XLNMOM + .1 | SS8B120 |
| NLMASS = XLMASS + .1 | SS8B121 |
| NPTSUP = XPTSUP + .1 | SS8B122 |
| NLNSPR = XLNSPR + .1 | SS8B123 |
| IFLEX = XFLEX + .1 | SS8B124 |
| C ** TEST THE VALUES READ IN | SS8B125 |
| IERROR = 0 | SS8B126 |
| IF (IFLAGD .LT. 0 .OR. IFLAGD .GT. 1) CALL CHECK ('IFLAGD') | SS8B127 |
| IF (IFLAGB .LT. 0 .OR. IFLAGB .GT. 2) CALL CHECK ('IFLAGB') | SS8B128 |
| IF (IFLAGW .LT. 0 .OR. IFLAGW .GT. 2) CALL CHECK ('IFLAGW') | SS8B129 |
| IF (IBCX .LT. 1 .OR. IBCX .GT. 7) CALL CHECK ('IBCX') | SS8B130 |
| IF (IBCY .LT. 0 .OR. IBCY .GT. 8) CALL CHECK ('IBCY') | SS8B131 |
| IF (IMATL .LT. 1 .OR. IMATL .GT. 4) CALL CHECK ('IMATL') | SS8B132 |
| IF (IEDGE .LT. 0 .OR. IEDGE .GT. 2) CALL CHECK ('IEDGE') | SS8B133 |
| IF (IOUT .LT. 1 .OR. IOUT .GT. 9) CALL CHECK ('IOUT') | SS8B134 |
| IF (IPRTN .LT. 0 .OR. IPRTN .GT. 1) CALL CHECK ('IPRTN') | SS8B135 |
| IF (IPRTQ .LT. 0 .OR. IPRTQ .GT. 1) CALL CHECK ('IPRTQ') | SS8B136 |
| IF (NPLYS .LT. 1 .OR. NPLYS .GT. 40) CALL CHECK ('NPLYS') | SS8B137 |
| IF (NTUX .LT. 1 .OR. NTUX .GT. 10) CALL CHECK ('NTUX') | SS8B138 |
| IF (NTVX .LT. 1 .OR. NTVX .GT. 10) CALL CHECK ('NTVX') | SS8B139 |
| IF (NTWX .LT. 1 .OR. NTWX .GT. 10) CALL CHECK ('NTWX') | SS8B140 |
| IF (NTUY .LT. 1 .OR. NTUY .GT. 10) CALL CHECK ('NTUY') | SS8B141 |
| IF (NTVY .LT. 1 .OR. NTVY .GT. 10) CALL CHECK ('NTVY') | SS8B142 |
| IF (NTWY .LT. 1 .OR. NTWY .GT. 10) CALL CHECK ('NTWY') | SS8B143 |
| IF (ITX .LT. 0 .OR. ITX .GT. 20) CALL CHECK ('ITX') | SS8B144 |
| IF (ITY .LT. 0 .OR. ITY .GT. 20) CALL CHECK ('ITY') | SS8B145 |
| IF (NSTRNG .LT. 0 .OR. NSTRNG .GT. 100) CALL CHECK ('NSTRNG') | SS8B146 |
| IF (NRING .LT. 0 .OR. NRING .GT. 50) CALL CHECK ('NRING') | SS8B147 |
| IF (NPNX .LT. 0 .OR. NPNX .GT. 10) CALL CHECK ('NPNX') | SS8B148 |
| IF (NPNY .LT. 0 .OR. NPNY .GT. 10) CALL CHECK ('NPNY') | SS8B149 |
| IF (NQTX .LT. 0 .OR. NQTX .GT. 10) CALL CHECK ('NQTX') | SS8B150 |
| IF (NQTY .LT. 0 .OR. NQTY .GT. 10) CALL CHECK ('NQTY') | SS8B151 |
| IF (NPTLDS .LT. 0 .OR. NPTLDS .GT. 50) CALL CHECK ('NPTLDS') | SS8B152 |
| IF (NPTMOM .LT. 0 .OR. NPTMOM .GT. 50) CALL CHECK ('NPTMOM') | SS8B153 |
| IF (NLNMOM .LT. 0 .OR. NLNMOM .GT. 50) CALL CHECK ('NLNMOM') | SS8B154 |
| IF (NLMASS .LT. 0 .OR. NLMASS .GT. 50) CALL CHECK ('NLMASS') | SS8B155 |
| IF (NPTSUP .LT. 0 .OR. NPTSUP .GT. 50) CALL CHECK ('NPTSUP') | SS8B156 |
| IF (NLNSPR .LT. 0 .OR. NLNSPR .GT. 50) CALL CHECK ('NLNSPR') | SS8B157 |
| IF (IFLEX .LT. 0 .OR. IFLEX .GT. 50) CALL CHECK ('IFLEX') | SS8B158 |
| MATSIZ = NTUX*NTUY + NTVX*NTVY + NTWX*NTWY | SS8B159 |
| IF (MATSIZ .LT. 1 .OR. MATSIZ .GT. 150) CALL CHECK ('MATSIZ') | SS8B160 |
| IF (NMODES .LT. 0 .OR. NMODES .GT. MATSIZ) CALL CHECK ('NMODES') | SS8B161 |
| IF (IBCX .EQ. 6 .AND. ITX .EQ. 1) CALL CHECK ('ITX') | SS8B162 |
| IF (IBCY .EQ. 6 .AND. ITY .EQ. 1) CALL CHECK ('ITY') | SS8B163 |
| IF (IERROR .EQ. 1) GO TO 99999 | SS8B164 |
| MWSIZ = NTWX*NTWY | SS8B165 |
| MUVSIZ = MATSIZ - MWSIZ | SS8B166 |
| MU = 0. | SS8B167 |

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| IF (IBCY .EQ. 0) GO TO 8 | SS88168 |
| IF (IKDF .EQ. 0) READ (5,5) AA, BB, RR | SS88169 |
| IF (IKDF .EQ. 1) READ (5,5) AA, BB, RR, MU | SS88170 |
| GO TO 9 | SS88171 |
| 8 IF (IKDF .EQ. 0) READ (5,5) AA, RR | SS88172 |
| IF (IKDF .EQ. 1) READ (5,5) AA, RR, MU | SS88173 |
| BB = 6.2831853 * RR | SS88174 |
| 9 CONTINUE | SS88175 |
| C ** THE BOUNDARY CONDITIONS ARE PRINTED | SS88176 |
| II = IBCX | SS88177 |
| IF (IBCY.NE.0) GO TO 20 | SS88178 |
| WRITE (6,10) | SS88179 |
| 10 FORMAT ('OTHE BOUNDARY CONDITIONS OF THE COMPLETE CYLINDER AT X=0 | SS88180 |
| AND X=A ARE') | SS88181 |
| GO TO 40 | SS88182 |
| 20 WRITE (6,150) | SS88183 |
| IBCTAG = +1 | SS88184 |
| GO TO 40 | SS88185 |
| 30 II=IBCY | SS88186 |
| WRITE (6,160) | SS88187 |
| IBCTAG = -1 | SS88188 |
| 40 IF (II-2) 70,80,50 | SS88189 |
| 50 IF (II-4) 90,100,60 | SS88190 |
| 60 IF (II-6) 110,120,130 | SS88191 |
| 70 WRITE (6,170) | SS88192 |
| GO TO 140 | SS88193 |
| 80 WRITE (6,180) | SS88194 |
| GO TO 140 | SS88195 |
| 90 WRITE (6,190) | SS88196 |
| GO TO 140 | SS88197 |
| 100 WRITE (6,200) | SS88198 |
| GO TO 140 | SS88199 |
| 110 WRITE (6,210) | SS88200 |
| GO TO 140 | SS88201 |
| 120 WRITE (6,220) | SS88202 |
| GO TO 140 | SS88203 |
| 130 WRITE (6,230) | SS88204 |
| 140 IF (IBCTAG.GT.0.AND.IBCY.NE.0) GO TO 30 | SS88205 |
| 150 FORMAT('OTHE BOUNDARY CONDITIONS AT X=0 AND X=A ARE') | SS88206 |
| 160 FORMAT('OTHE BOUNDARY CONDITIONS AT Y=0 AND Y=B ARE') | SS88207 |
| 170 FORMAT(' CLAMPED, SIMPLE') | SS88208 |
| 180 FORMAT(' SIMPLE, SIMPLE') | SS88209 |
| 190 FORMAT(' CLAMPED, CLAMPED') | SS88210 |
| 200 FORMAT(' CLAMPED, FREE') | SS88211 |
| 210 FORMAT(' SIMPLE, FREE') | SS88212 |
| 220 FORMAT(' FREE, FREE') | SS88213 |
| 230 FORMAT(' ELASTIC RESTRAINT') | SS88214 |
| WRITE (6,240) NTUX,ITX,NTUY,ITY,MATSIZ,MATSIZ | SS88215 |
| 240 FORMAT ('OTHER ARE' ,I3,' MODES IN THE X DIRECTION, STARTING WITH | SS88216 |
| 1 M =' ,I3,' .' / ' THERE ARE' ,I3,' MODES IN THE Y DIRECTION, STARTING | SS88217 |
| 2 WITH N =' ,I3,' .' / 'OTHE STIFFNESS MATRIX SIZE IS' I4,' BY' I4) | SS88218 |
| IF (IFLAGD.NE.0) WRITE (6,250) | SS88219 |
| 250 FORMAT('OA DYNAMIC SOLUTION WILL BE SOUGHT') | SS88220 |
| IF (IFLAGB.NE.0) WRITE (6,260) | SS88221 |
| 260 FORMAT('OA STABILITY SOLUTION WILL BE SOUGHT') | SS88222 |
| IF (IFLAGW.NE.0) WRITE (6,270) | SS88223 |

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| 270 | FORMAT('0A SOLUTION UNDER LATERAL LOADS WILL BE SOUGHT') | SS8B224 |
| | WRITE (6,280) AA, BB, RR, MU | SS8B225 |
| 280 | FORMAT ('0A ='F20.5/'0B ='F20.5/'0R ='F20.5/'0MU ='F19.5) | SS8B226 |
| C ** | ELASTIC RESTRAINT | SS8B227 |
| | IELAST = 1 | SS8B228 |
| | ALFAX = 0. | SS8B229 |
| | BETAX = 0. | SS8B230 |
| | ALFAY = 0. | SS8B231 |
| | BETAY = 0. | SS8B232 |
| | IF (IBCX.EQ.7.AND.IBCY.LT.7) GO TO 290 | SS8B233 |
| | IF (IBCX.EQ.7.AND.IBCY.EQ.7) GO TO 300 | SS8B234 |
| | IF (IBCX.NE.7.AND.IBCY.EQ.8) GO TO 310 | SS8B235 |
| | IF (IBCX.EQ.7.AND.IBCY.EQ.8) GO TO 320 | SS8B236 |
| | GO TO 330 | SS8B237 |
| 290 | IELAST = 2 | SS8B238 |
| | READ (5,5) ALFAX,BETAX | SS8B239 |
| | GO TO 330 | SS8B240 |
| 300 | IELAST = 3 | SS8B241 |
| | READ (5,5) ALFAX,BETAX | SS8B242 |
| | ALFAY = ALFAX | SS8B243 |
| | BETAY = BETAX | SS8B244 |
| | GO TO 330 | SS8B245 |
| 310 | IELAST = 4 | SS8B246 |
| | READ (5,5) ALFAY,BETAY | SS8B247 |
| | GO TO 330 | SS8B248 |
| 320 | IELAST = 5 | SS8B249 |
| | READ (5,5) ALFAX,BETAX,ALFAY,BETAY | SS8B250 |
| 330 | CONTINUE | SS8B251 |
| | IF (IELAST.EQ.1) GO TO 350 | SS8B252 |
| | WRITE (6,340) ALFAX,BETAX,ALFAY,BETAY | SS8B253 |
| 340 | FORMAT ('0THE ELASTIC RESTRAINT QUANTITIES ARE -- ' / ' ALFAX = 'E16.8 / ' BETAX = 'E16.8 / ' ALFAY = 'E16.8 / ' BETAY = 'E16.8) | SS8B254 |
| | 1 E16.8 / ' BETAX = 'E16.8 / ' ALFAY = 'E16.8 / ' BETAY = 'E16.8) | SS8B255 |
| 350 | CONTINUE | SS8B256 |
| C ** | READ IN NECESSARY MATERIAL PROPERTIES THROUGH STATEMENT 470 | SS8B257 |
| | DO 360 I=1,3 | SS8B258 |
| | DO 360 J=1,3 | SS8B259 |
| | AMAT(I,J)=0. | SS8B260 |
| | BMAT(I,J)=0. | SS8B261 |
| | DMAT(I,J)=0. | SS8B262 |
| 360 | CONTINUE | SS8B263 |
| | IF (IMATL . EQ . 1) GO TO 370 | SS8B264 |
| | IF (IMATL . EQ . 2) GO TO 390 | SS8B265 |
| | IF (IMATL . EQ . 3) GO TO 450 | SS8B266 |
| C ** | SANDWICH | SS8B267 |
| | DO 361 J=1,3,2 | SS8B268 |
| | READ (5,5) E1(J), E2(J), G(J), XNU12(J), H(J) | SS8B269 |
| | THETA(J) = 0. | SS8B270 |
| | IF (IOUT .LT. 7) GO TO 361 | SS8B271 |
| | READ (5,5) (EC(I,J),I=1,3), (ET(I,J),I=1,3), XCHK | SS8B272 |
| | MCHK(J) = XCHK + .1 | SS8B273 |
| | NCHK = MCHK(J) | SS8B274 |
| | IF (NCHK .LT. 1 .OR.NCHK .GT. 10) CALL CHECK ('MCHK ') | SS8B275 |
| | IF (IERROR .EQ. 1) GO TO 9999 | SS8B276 |
| | READ(5,5) (ANGCK(J,I), I=1,NCHK) | SS8B277 |
| 361 | CONTINUE | SS8B278 |
| | READ (5,5) H(2) | SS8B279 |

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E1(2) = 1. SS88280
E2(2) = 1. SS88281
G(2) = 1. SS88282
XNU12(2) = .25 SS88283
THETA(2) = 0. SS88284
DO 362 J=1,3,2 SS88285
NCHK = MCHK(J) SS88286
IF ( J.EQ.1 ) K=KIN SS88287
IF ( J.EQ.3 ) K=KOUT SS88288
IF ( IOUT .LT. 7 ) WRITE(6,366) K,E1(J),E2(J),G(J),XNU12(J),H(J) SS88289
366 FORMAT ('OFOR THE ',A3,'ER FACING OF THE SANDWICH, E1 =',E14.6 SS88290
1,', E2 =',E14.6,', G =',E14.6,', NU12 =',F7.3,', H =',F8.3) SS88291
IF ( IOUT .GE. 7 ) SS88292
1WRITE (6,363) K, E1(J), E2(J), G(J), XNU12(J), H(J), SS88293
1 ( EC(I,J), I=1,3), ( ET(I,J), I=1,3), SS88294
2 ( ANGCK(J,I), I=1,NCHK ) SS88295
363 FORMAT ('OFOR THE ',A3,'ER FACING OF THE SANDWICH, E1 =', SS88296
1 E14.6,', E2 =',E14.6,', G =',E14.6,', NU12 =',F7.3, SS88297
2 ', H =',F8.3//9X,'THE COMPRESSION ALLOWABLES IN THE 1, 2, SS88298
3AND 12 DIRECTIONS ARE',3E15.6, ' IN./IN.'//9X, SS88299
4 'THE TENSION ALLOWABLES IN THE 1, 2, AND 12 DIRECTIONSSS88300
5 ARE',3E15.6, ' IN./IN.'//9X,'THE ORIENTATIONS TO BE CHECKEDSS88301
6 ARE',10F8.2) SS88302
362 CONTINUE SS88303
WRITE (6,364) H(2) SS88304
364 FORMAT ('OTHE CORE THICKNESS IS',F9.3,' IN.') SS88305
T = H(1) + H(2) + H(3) SS88306
WRITE (6,365) T SS88307
365 FORMAT ('OTHE TOTAL SANDWICH THICKNESS IS',F9.3,' IN.') SS88308
GO TO 410 SS88309
C ** ISOTROPIC -- READ E, NU, AND T SS88310
370 READ (5,5) E1(1), XNU12(1), T SS88311
IF ( IOUT .GE. 7 ) READ(5,5) (EC(I,1),I=1,3), (ET(I,1),I=1,3) SS88312
WRITE (6,380) E1(1),XNU12(1),T SS88313
380 FORMAT ('OFOR THE ISOTROPIC MATERIAL, E =',E16.7,', NU =',F7.4, SS88314
1 ', T =',F9.4 ) SS88315
IF ( IOUT .GE. 7 )WRITE(6,381)(EC(I,1),I=1,3), (ET(I,1),I=1,3) SS88316
381 FORMAT ('O',8X,'THE COMPRESSION ALLOWABLES IN THE 1, 2, AND 12 DIRSS88317
1ECTIONS ARE',3E15.6,' IN./IN.'//9X,'THE TENSION ALLOWABLES IN THE SS88318
21, 2, AND 12 DIRECTIONS ARE',3E15.6,' IN./IN.') SS88319
AMAT(1,1) = E1(1)*T/(1.-XNU12(1)*XNU12(1)) SS88320
AMAT(2,2) = AMAT(1,1) SS88321
AMAT(2,1) = XNU12(1)*AMAT(1,1) SS88322
AMAT(1,2) = AMAT(2,1) SS88323
AMAT(3,3) = E1(1)*T/2./(1.+XNU12(1)) SS88324
DMAT(1,1) = E1(1)*T*T*T/12./(1.-XNU12(1)*XNU12(1)) SS88325
DMAT(2,2) = DMAT(1,1) SS88326
DMAT(2,1) = XNU12(1)*DMAT(1,1) SS88327
DMAT(1,2) = DMAT(2,1) SS88328
DMAT(3,3) = E1(1)*T*T*T/24./(1.+XNU12(1)) SS88329
E2(1) = E1(1) SS88330
H(1) = T SS88331
G(1) = E1(1)/2./(1+XNU12(1)) SS88332
THETA(1) = 0. SS88333
GO TO 410 SS88334
C ** LAMINATE WITH CONSTANT PLY PROPERTIES SS88335

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390 READ (5,5) E1(1), E2(1), G(1), XNU12(1), H(1), SS88336
1      ( THETA(I), I=1,NPLYS ) SS88337
IF ( IOUT .GE. 7 ) READ (5,5) (EC(I,1),I=1,3), (ET(I,1),I=1,3) SS88338
T = H(1)*NPLYS SS88339
WRITE (6,400) NPLYS, E1(1), E2(1), G(1), XNU12(1), H(1), SS88340
1      T, ( THETA(I), I=1,NPLYS ) SS88341
400 FORMAT ('O FOR THE ',I2,' PLY LAMINATE'/'OE1 =' E20.6 /'OE2 =' , SS88342
1      E20.6 / 'OG =' E20.6 / 'ONU12 =' F6.4 / 'OH(I) =' F9.4/ SS88343
2      'OT =' F9.4 / 'OTHE ORIENTATIONS ARE'/( ' F10.4/ ) ) SS88344
IF ( IOUT .GE. 7 ) WRITE(6,381) (EC(I,1),I=1,3), (ET(I,1),I=1,3) SS88345
DO 409 I=1,NPLYS SS88346
E1(I) = E1(1) SS88347
E2(I) = E2(1) SS88348
G(I) = G(1) SS88349
XNU12(I) = XNU12(1) SS88350
H(I) = H(1) SS88351
DO 409 J=1,3 SS88352
EC(J,I) = EC(J,1) SS88353
ET(J,I) = ET(J,1) SS88354
409 CONTINUE SS88355
410 CALL STIFF SS88356
420 WRITE (6,430) ((AMAT(I,J),J=1,3),(BMAT(I,J),J=1,3),I=1,3) SS88357
WRITE (6,440) ((BMAT(I,J),J=1,3),(DMAT(I,J),J=1,3),I=1,3) SS88358
430 FORMAT ('THE CONSTITUTIVE MATRIX IS' / / / (6E16.7)) SS88359
440 FORMAT (6E16.7) SS88360
C ** FIX FOR ELASTIC RESTRAINT SS88361
IF ( IELAST .EQ. 1 ) GO TO 431 SS88362
ALFAX = ALFAX * AA / DMAT(1,1) SS88363
BETAX = BETAX * AA / DMAT(1,1) SS88364
ALFAY = ALFAY * BB / DMAT(2,2) SS88365
BETAY = BETAY * BB / DMAT(2,2) SS88366
431 CONTINUE SS88367
IF ( IMATL .EQ. 1 ) GO TO 470 SS88368
DO 601 I=1,3 SS88369
DO 601 J=1,3 SS88370
601 A(I,J) = AMAT(I,J) SS88371
DET = A(1,1)*A(2,2)*A(3,3) + A(1,2)*A(2,3)*A(3,1) SS88372
+ A(1,3)*A(2,1)*A(3,2) - A(1,3)*A(2,2)*A(3,1) SS88373
- A(1,1)*A(2,3)*A(3,2) - A(1,2)*A(2,1)*A(3,3) SS88374
AI(1,1) = ( A(2,2)*A(3,3) - A(2,3)*A(3,2) ) / DET SS88375
AI(1,2) = ( A(2,3)*A(3,1) - A(2,1)*A(3,3) ) / DET SS88376
AI(1,3) = ( A(2,1)*A(3,2) - A(2,2)*A(3,1) ) / DET SS88377
AI(2,2) = ( A(1,1)*A(3,3) - A(1,3)*A(3,1) ) / DET SS88378
AI(2,3) = ( A(1,2)*A(3,1) - A(1,1)*A(3,2) ) / DET SS88379
AI(3,3) = ( A(1,1)*A(2,2) - A(1,2)*A(2,1) ) / DET SS88380
EX = 1. / AI(1,1) / T SS88381
EY = 1. / AI(2,2) / T SS88382
GXY = 1. / AI(3,3) / T SS88383
XNUXY = - AI(1,2) / AI(1,1) SS88384
XNUYX = - AI(1,2) / AI(2,2) SS88385
WRITE(6,441) SS88386
441 FORMAT ('OTHE LAMINATE PROPERTIES ARE') SS88387
WRITE (6,442) EX,EY,GXY,XNUXY,XNUYX SS88388
442 FORMAT ('OEX =' ,E15.6,3X,'EY =' ,E15.6,3X,'G =' ,E15.6,3X,'NUXY =' , SS88389
1      F8.4,3X,'NUYX =' ,F8.4) SS88390
GO TO 470 SS88391

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C ** LAMINATE WITH VARIABLE PLY PROPERTIES SS88392
450 IF ( IOUT .LT. 7 ) SS88393
    1 READ (5,5) ( E1(I), E2(I), G(I), XNU12(I), H(I), THETA(I), I=1, NPLYS ) SS88394
    IF ( IOUT .GE. 7 ) READ (5,5) ( E1(I), E2(I), G(I), XNU12(I), SS88395
    1 H(I), THETA(I), (EC(J,I), J=1,3), (ET(J,I), J=1,3), I=1, NPLYS ) SS88396
    T = 0. SS88397
    DO 461 I=1, NPLYS SS88398
    WRITE(6,460) I, H(I), E1(I), E2(I), XNU12(I), G(I), THETA(I) SS88399
460 FORMAT('OPLY' I4, ' HAS A THICKNESS OF ' F11.7, ' E1=' E16.7, ' E2=' E16. SS88400
177 ' NUI2=' F6.4, ' G=' E16.7, ' AND ORIENTATION=' F10.3, ' DEGR SS88401
2EES.' ) SS88402
    IF ( IOUT .GE. 7 ) WRITE(6,381) (EC(J,I), J=1,3), (ET(J,I), J=1,3) SS88403
461 T = T + H(I) SS88404
    WRITE (6,462) T SS88405
462 FORMAT ('OT = ' , F9.4, ' IN.' ) SS88406
    GO TO 410 SS88407
470 CONTINUE SS88408
    IF ( NSTRNG .EQ. 0 ) GO TO 490 SS88409
C ** FOR STRINGERS SS88410
    IF ( IEQS .EQ. 1 ) GO TO 471 SS88411
    READ (5,5) ( YSTRNG(L), YBARS(L), ZBARS(L), AS(L), XIYYS(L), SS88412
    1 XIYZS(L), XIZZS(L), ES(L), GJS(L), RHOS(L), SS88413
    2 L=1, NSTRNG ) SS88414
    WRITE (6,477) SS88415
477 FORMAT ('OTHE STRINGER PROPERTIES FOLLOW --') SS88416
    WRITE(6,479) SS88417
479 FORMAT ('O', T2, 'L', T9, 'Y', T16, 'YBAR', T23, 'ZBAR', T30, 'AREA', SS88418
    1 T40, 'IYY', T52, 'IYZ', T64, 'IZZ', T77, 'E', T88, 'GJ', T100, SS88419
    2 'RHO' / ) SS88420
    WRITE(6,480) (L, YSTRNG(L), YBARS(L), ZBARS(L), AS(L), XIYYS(L), SS88421
    1 XIYZS(L), XIZZS(L), ES(L), GJS(L), RHOS(L), SS88422
    2 L=1, NSTRNG ) SS88423
480 FORMAT (1X, OPI3, F9.2, 3F7.2, 1P6E12.4) SS88424
    GO TO 489 SS88425
471 READ (5,5) YBARS(1), ZBARS(1), AS(1), XIYYS(1), XIYZS(1), SS88426
    1 XIZZS(1), ES(1), GJS(1), RHOS(1) SS88427
    YSTRNG(1) = BB / (NSTRNG + 1) SS88428
    IF ( IBCY .EQ. 0 ) YSTRNG(1) = BB / NSTRNG SS88429
    DO 472 L=2, NSTRNG SS88430
    YSTRNG(L) = L * YSTRNG(1) SS88431
    YBARS(L) = YBARS(1) SS88432
    ZBARS(L) = ZBARS(1) SS88433
    AS(L) = AS(1) SS88434
    XIYYS(L) = XIYYS(1) SS88435
    XIYZS(L) = XIYZS(1) SS88436
    XIZZS(L) = XIZZS(1) SS88437
    ES(L) = ES(1) SS88438
    GJS(L) = GJS(1) SS88439
472 RHOS(L) = RHOS(1) SS88440
    WRITE (6,473) NSTRNG SS88441
473 FORMAT ('OTHER ARE ', I3, ' EQUALLY SPACED STRINGERS EACH OF WHICH SS88442
    1 HAS THE FOLLOWING PROPERTIES --') SS88443
    WRITE (6,474) SS88444
474 FORMAT ('O', T6, 'SPACING ', T16, 'YBAR', T23, 'ZBAR', T30, 'AREA', SS88445
    1 T40, 'IYY', T52, 'IYZ', T64, 'IZZ', T77, 'E', T88, 'GJ', T100, SS88446
    2 'RHO' / ) SS88447

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| WRITE (6,475) YSTRNG(1), YBARS(1), ZBARS(1), AS(1), XIYYS(1), | SS8B448 |
| 1 XIYZS(1), XIZZS(1), ES(1), GJS(1), RHOS(1) | SS8B449 |
| 475 FORMAT (4X,F9.2,3F7.2,1P6E12.4) | SS8B450 |
| 489 DO 476 L=1,NSTRNG | SS8B451 |
| 476 YSTRNG(L) = YSTRNG(L)/BB | SS8B452 |
| 490 CONTINUE | SS8B453 |
| IF (NRING .EQ. 0) GO TO 510 | SS8B454 |
| C ** FOR RINGS | SS8B455 |
| IF (IEQR .EQ. 1) GO TO 501 | SS8B456 |
| READ (5,5) (XRINGS(K), XBARR(K), ZBARR(K), AR(K), XIXXR(K), | SS8B457 |
| 1 XIXZR(K), XIZZR(K), ER(K), GJR(K), RHOR(K), | SS8B458 |
| 2 K=1,NRING) | SS8B459 |
| WRITE (6,498) | SS8B460 |
| 498 FORMAT ('OTHE RING PROPERTIES FOLLOW --') | SS8B461 |
| WRITE (6,500) | SS8B462 |
| 500 FORMAT ('O',T2,'K',T9,'X',T16,'XBAR',T23,'ZBAR',T30,'AREA', | SS8B463 |
| 1 T40,'IXX',T52,'IXZ',T64,'IZZ',T77,'E',T88,'GJ',T100, | SS8B464 |
| 2 'RHO'/) | SS8B465 |
| WRITE(6,480)(K,XRINGS(K), XBARR(K), ZBARR(K), AR(K), XIXXR(K), | SS8B466 |
| 1 XIXZR(K), XIZZR(K), ER(K), GJR(K), RHOR(K), | SS8B467 |
| 2 K=1,NRING) | SS8B468 |
| GO TO 509 | SS8B469 |
| 501 READ (5,5) XBARR(1), ZBARR(1), AR(1), XIXXR(1), XIXZR(1), | SS8B470 |
| 1 XIZZR(1), ER(1), GJR(1), RHOR(1) | SS8B471 |
| XRINGS(1) = AA/(NRING + 1) | SS8B472 |
| DO 502 K=2,NRING | SS8B473 |
| XRINGS(K) = K * XRINGS(1) | SS8B474 |
| XBARR(K) = XBARR(1) | SS8B475 |
| ZBARR(K) = ZBARR(1) | SS8B476 |
| AR(K) = AR(1) | SS8B477 |
| XIXXR(K) = XIXXR(1) | SS8B478 |
| XIXZR(K) = XIXZR(1) | SS8B479 |
| XIZZR(K) = XIZZR(1) | SS8B480 |
| ER(K) = ER(1) | SS8B481 |
| GJR(K) = GJR(1) | SS8B482 |
| 502 RHOR(K) = RHOR(1) | SS8B483 |
| WRITE (6,503) NRING | SS8B484 |
| 503 FORMAT ('OTHER ARE ',I2,' EQUALLY SPACED RINGS EACH OF WHICH HAS | SS8B485 |
| 1THE FOLLOWING PROPERTIES --') | SS8B486 |
| WRITE (6,504) | SS8B487 |
| 504 FORMAT ('O',T6,'SPACING ',T16,'XBAR',T23,'ZBAR',T30,'AREA', | SS8B488 |
| 1 T40,'IXX',T52,'IXZ',T64,'IZZ',T77,'E',T88,'GJ',T100, | SS8B489 |
| 2 'RHO'/) | SS8B490 |
| WRITE (6,475) XRINGS(1), XBARR(1), ZBARR(1), AR(1), XIXXR(1), | SS8B491 |
| 1 XIXZR(1), XIZZR(1), ER(1), GJR(1), RHOR(1) | SS8B492 |
| 509 DO 505 K=1,NRING | SS8B493 |
| 505 XRINGS(K) = XRINGS(K) / AA | SS8B494 |
| 510 CONTINUE | SS8B495 |
| IF (IFLAGD .EQ. 0) GO TO 550 | SS8B496 |
| C ** IF DOING DYNAMICS, READ AVERAGE MATERIAL DENSITY | SS8B497 |
| READ (5,5) DENSE | SS8B498 |
| WRITE (6,520) DENSE | SS8B499 |
| 520 FORMAT ('OTHE MATERIAL DENSITY = 'E15.8,' LB.-SEC.**2/IN.**4') | SS8B500 |
| RHAB = DENSE * T * AA * BB | SS8B501 |
| IF (NLMASS .EQ. 0) GO TO 550 | SS8B502 |
| C ** HAVE LUMPED MASSES | SS8B503 |

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| DO 530 I=1,NLMASS | SS88504 |
| READ (5,5) X, Y, PMASS(I) | SS88505 |
| IPWW(I) = X + .1 | SS88506 |
| IPWY(I) = Y + .1 | SS88507 |
| 530 WRITE (6,540) IPWW(I), IPWY(I), PMASS(I) | SS88508 |
| 540 FORMAT ('OTHER IS A LUMPED MASS AT COORDINATES'13,', '13, | SS88509 |
| 1 ' OF MAGNITUDE'E15.7,' LB-SEC**2/IN') | SS88510 |
| 550 CONTINUE | SS88511 |
| IF (IEDGE .EQ. 0) GO TO 610 | SS88512 |
| C ** READ EDGE LOADS | SS88513 |
| IF (IBCY .EQ. 0 .AND. IEDGE .EQ. 2) CALL CYLNDR (&571) | SS88514 |
| IF (NPNX .GT. 0 .AND. NPNY .GT. 0) GO TO 570 | SS88515 |
| WRITE (6,560) | SS88516 |
| 560 FORMAT ('EDGE LOADS ARE TO BE INCLUDED BUT NPNX OR NPNY IS ZERO.' | SS88517 |
| 1 '/' THIS PROBLEM IS TERMINATED.') | SS88518 |
| GO TO 99999 | SS88519 |
| 570 READ (5,5) ((PX(J,I), PY(J,I), PXY(J,I), J=1,NPNX), I=1,NPNY) | SS88520 |
| 571 CONTINUE | SS88521 |
| IEDGE = 1 | SS88522 |
| WRITE (6,580) ((PX(J,I), J=1,NPNX), I=1,NPNY) | SS88523 |
| 580 FORMAT ('OPX(I,J) FOLLOWS'/(1P10E12.4)) | SS88524 |
| WRITE (6,590) ((PY(J,I), J=1,NPNX), I=1,NPNY) | SS88525 |
| 590 FORMAT ('OPY(I,J) FOLLOWS'/(1P10E12.4)) | SS88526 |
| WRITE (6,600) ((PXY(J,I), J=1,NPNX), I=1,NPNY) | SS88527 |
| 600 FORMAT ('OPXY(I,J) FOLLOWS'/(1P10E12.4)) | SS88528 |
| IF (NSTRNG + NRING .EQ. 0) GO TO 610 | SS88529 |
| IF (NSTRNG .EQ. 0) GO TO 608 | SS88530 |
| DO 604 L=1,NSTRNG | SS88531 |
| V(1,1) = 1. | SS88532 |
| Y = YSTRNG(L) | SS88533 |
| DO 602 K=2,NPNY | SS88534 |
| 602 V(1,K) = Y ** (K-1) | SS88535 |
| XNX = 0. | SS88536 |
| DO 603 K=1,NPNY | SS88537 |
| 603 XNX = XNX + PX(1,K) * V(1,K) | SS88538 |
| 604 PAXS(L) = XNX * AS(L) * ES(L) / EX / T | SS88539 |
| IF (NPNY .EQ. 1 .AND. IEQS .EQ. 1) WRITE (6,605) PAXS(1) | SS88540 |
| 605 FORMAT ('OTHE AXIAL LOAD CARRIED BY EACH STRINGER IS ',E12.5,' LBS | SS88541 |
| 1.'') | SS88542 |
| IF (NPNY .NE. 1 .OR. IEQS .EQ. 0) WRITE (6,606) | SS88543 |
| 606 FORMAT ('OTHE AXIAL LOADS (LBS.) CARRIED BY THE STRINGERS FOLLOW | SS88544 |
| 1 --') | SS88545 |
| IF(NPNY.NE.1.OR.IEQS.EQ.0) WRITE(6,607)(L,PAXS(L),L=1,NSTRNG) | SS88546 |
| 607 FORMAT ('O',8(13,E13.5)) | SS88547 |
| 608 IF (NRING .EQ. 0) GO TO 610 | SS88548 |
| IF (IBCY .EQ. 0) GO TO 610 | SS88549 |
| V(1,1) = 1. | SS88550 |
| DO 612 K=1,NRING | SS88551 |
| X = XRINGS(K) | SS88552 |
| DO 609 L=2,NPNX | SS88553 |
| 609 V(1,L) = X ** (L-1) | SS88554 |
| XNY = 0. | SS88555 |
| DO 611 L=1,NPNX | SS88556 |
| 611 XNY = XNY + PY(L,1) * V(1,L) | SS88557 |
| 612 PAXR(K) = XNY * AR(K) * ER(K) / EY / T | SS88558 |
| IF (NPNX .EQ. 1 .AND. IEQR .EQ. 1) WRITE (6,613) PAXR(1) | SS88559 |

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| 613 | FORMAT ('OTHE LOAD CARRIED BY EACH RING IS ',E12.5,' LBS.') | SS8B560 |
| | IF (NPNX .NE. 1 .OR. IEQR .EQ. 0) WRITE (6,614) | SS8B561 |
| 614 | FORMAT ('OTHE LOADS (LBS.) CARRIED BY THE RINGS FOLLOW --') | SS8B562 |
| | IF(NPNX.NE.1.OR.IEQR.EQ.0) WRITE(6,607)(K,PAXR(K),K=1,NRING) | SS8B563 |
| 610 | CONTINUE | SS8B564 |
| | IF (IFLAGW .NE. 1) GO TO 650 | SS8B565 |
| C ** | READ LATERAL LOADS | SS8B566 |
| | IF (NQTX .GT. 0 .AND. NQTY .GT. 0) GO TO 630 | SS8B567 |
| | WRITE (6,620) | SS8B568 |
| 620 | FORMAT ('ILATERAL LOADS ARE TO BE INCLUDED BUT NQTX OR NQTY IS ZER | SS8B569 |
| | 10.' /' THIS PROBLEM IS TERMINATED.') | SS8B570 |
| | GO TO 99999 | SS8B571 |
| 630 | READ (5,5) ((Q(J,I), J=1,NQTX), I=1,NQTY) | SS8B572 |
| | WRITE(6,640)((Q(J,I), J=1,NQTX), I=1,NQTY) | SS8B573 |
| 640 | FORMAT ('OQ(I,J) FOLLOWS' / (1P10E12.4)) | SS8B574 |
| 650 | CONTINUE | SS8B575 |
| | IF (NPTLDS .EQ. 0) GO TO 680 | SS8B576 |
| C ** | HAVE POINT LOADS | SS8B577 |
| | DO 660 I=1,NPTLDS | SS8B578 |
| | READ (5,5) X, Y, DUM | SS8B579 |
| | IPXX(I) = X + .1 | SS8B580 |
| | IPYY(I) = Y + .1 | SS8B581 |
| | PC(I) = DUM | SS8B582 |
| 660 | WRITE (6,670) IPXX(I), IPYY(I), PC(I) | SS8B583 |
| 670 | FORMAT ('OTHER IS A CONCENTRATED LOAD AT COORDINATES'I3,', 'I3, | SS8B584 |
| | 1 ' OF MAGNITUDE'F12.5,' LBS.') | SS8B585 |
| 680 | CONTINUE | SS8B586 |
| | IF (NPTMOM .EQ. 0) GO TO 710 | SS8B587 |
| C ** | HAVE POINT MOMENTS | SS8B588 |
| | DO 690 I=1,NPTMOM | SS8B589 |
| | READ (5,5) X, Y, TAG, DUM | SS8B590 |
| | IFXX(I) = X + .1 | SS8B591 |
| | IFYY(I) = Y + .1 | SS8B592 |
| | FC(I) = DUM | SS8B593 |
| | ITAGCM(I) = TAG + .1 | SS8B594 |
| | DIR = XDIR | SS8B595 |
| | IF (ITAGCM(I) .EQ. 2) DIR = YDIR | SS8B596 |
| 690 | WRITE (6,700) DIR, IFXX(I), IFYY(I), FC(I) | SS8B597 |
| 700 | FORMAT ('OTHER IS A CONCENTRATED MOMENT ABOUT THE ',A1,' AXIS AT | SS8B598 |
| | 1COORDINATES'I3,', 'I3,' OF MAGNITUDE'E15.7,' IN.-LBS.') | SS8B599 |
| 710 | CONTINUE | SS8B600 |
| | IF (NLNMOM .EQ. 0) GO TO 750 | SS8B601 |
| C ** | HAVE LINE MOMENTS | SS8B602 |
| | DO 730 I=1,NLNMOM | SS8B603 |
| | READ (5,5) TAG, DIST, PLMOM(I) | SS8B604 |
| | ITAGLM(I) = TAG + .1 | SS8B605 |
| | IDISLM(I) = DIST + .1 | SS8B606 |
| | IF (ITAGLM(I) .EQ. 2) GO TO 720 | SS8B607 |
| | DIR = XDIR | SS8B608 |
| | GO TO 730 | SS8B609 |
| 720 | DIR = YDIR | SS8B610 |
| 730 | WRITE (6,740) DIR, IDISLM(I), PLMOM(I) | SS8B611 |
| 740 | FORMAT ('OTHER IS A LINE MOMENT PARALLEL TO THE ',A1,' AXIS ON | SS8B612 |
| | 1RID LINE ', I2,' WITH A MAGNITUDE OF ',E15.7,' IN-LB/IN') | SS8B613 |
| 750 | CONTINUE | SS8B614 |
| | IF (NPTSUP .EQ. 0) GO TO 780 | SS8B615 |

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| C ** HAVE POINT SPRINGS SPECIFIED AT GRID POINTS | SS88616 |
| DO 760 I=1,NPTSUP | SS88617 |
| READ (5,5) X, Y, PKC(I) | SS88618 |
| IGSPRX(I) = X + .1 | SS88619 |
| IGSPRY(I) = Y + .1 | SS88620 |
| 760 WRITE (6,770) IGSPRX(I), IGSPRY(I), PKC(I) | SS88621 |
| 770 FORMAT('OTHER IS AN ELASTIC SUPPORT AT COORDINATES',I3,',',I3, | SS88622 |
| 1 ' WITH A SPRING CONSTANT OF'E16.8,' LB/IN.') | SS88623 |
| 780 CONTINUE | SS88624 |
| IF (NLNSPR .EQ. 0) GO TO 830 | SS88625 |
| C ** HAVE LINE SPRINGS | SS88626 |
| DO 810 I=1,NLNSPR | SS88627 |
| READ (5,5) TAG, DIST, PLINE(I) | SS88628 |
| ITAGLS(I) = TAG + .1 | SS88629 |
| IDISLS(I) = DIST + .1 | SS88630 |
| DIR = XDIR | SS88631 |
| IF (ITAGLS(I) .EQ. 2) DIR = YDIR | SS88632 |
| 810 WRITE (6,820) DIR, IDISLS(I), PLINE(I) | SS88633 |
| 820 FORMAT ('OTHER IS A LINE SPRING PARALLEL TO THE ',A1,' AXIS ON | SS88634 |
| GRID LINE ',I2,' WITH A SPRING CONSTANT OF ',E15.7,' LB/IN/IN.') | SS88635 |
| 830 CONTINUE | SS88636 |
| IF (IPRTN + IPRTQ .EQ. 0) GO TO 950 | SS88637 |
| DO 890 I=1,5 | SS88638 |
| X = .25 * (I-1) | SS88639 |
| V(1,1) = 1. | SS88640 |
| DO 840 K=2,10 | SS88641 |
| 840 V(1,K) = X ** (K-1) | SS88642 |
| DO 890 J=1,5 | SS88643 |
| Y = .25 * (J-1) | SS88644 |
| V(2,1) = 1. | SS88645 |
| DO 850 K=2,10 | SS88646 |
| 850 V(2,K) = Y ** (K-1) | SS88647 |
| PRTNX(I,J) = 0. | SS88648 |
| PRTNY(I,J) = 0. | SS88649 |
| PRTNXY(I,J) = 0. | SS88650 |
| PRTQ(I,J) = 0. | SS88651 |
| IF (IPRTN .EQ. 0) GO TO 870 | SS88652 |
| DO 860 K=1,NPNX | SS88653 |
| DO 860 L=1,NPNY | SS88654 |
| PRTNX (I,J) = PRTNX (I,J) + PX (K,L) * V(1,K) * V(2,L) | SS88655 |
| PRTNY (I,J) = PRTNY (I,J) + PY (K,L) * V(1,K) * V(2,L) | SS88656 |
| 860 PRTNXY(I,J) = PRTNXY(I,J) + PXY(K,L) * V(1,K) * V(2,L) | SS88657 |
| 870 IF (IPRTQ .EQ. 0) GO TO 890 | SS88658 |
| DO 880 K=1,NQTX | SS88659 |
| DO 880 L=1,NQTY | SS88660 |
| 880 PRTQ(I,J) = PRTQ(I,J) + Q(K,L) * V(1,K) * V(2,L) | SS88661 |
| 890 CONTINUE | SS88662 |
| IF (IPRTN .EQ. 0) GO TO 930 | SS88663 |
| WRITE (6,900) | SS88664 |
| 900 FORMAT ('INX, NY, AND NXY, RESPECTIVELY, ARE PRINTED AT QUARTER POS | SS88665 |
| INTS OF THE PANEL'//) | SS88666 |
| WRITE (6,910) ((PRTNX(I,J), J=1,5), I=1,5) | SS88667 |
| 910 FORMAT (' ',5E20.7) | SS88668 |
| WRITE (6,920) | SS88669 |
| 920 FORMAT ('0') | SS88670 |
| WRITE (6,910) ((PRTNY(I,J), J=1,5), I=1,5) | SS88671 |

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| WRITE (6,920) | SS88672 |
| WRITE (6,910) ((PRTNXY(I,J), J=1,5), I=1,5) | SS88673 |
| 930 IF (IPRTQ .EQ. 0) GO TO 950 | SS88674 |
| WRITE (6,940) | SS88675 |
| 940 FORMAT ('THE LATERAL LOAD DISTRIBUTION IS PRINTED AT QUARTER POINTS OF THE PANEL'//) | SS88676 |
| WRITE (6,910) ((PRTQ(I,J), J=1,5), I=1,5) | SS88677 |
| 950 CONTINUE | SS88678 |
| IF (IFLEX .EQ. 0) GO TO 970 | SS88679 |
| READ (5,5) (XP(I), YP(I), I=1,IFLEX) | SS88680 |
| WRITE (6,960) IFLEX, (XP(I), YP(I), I=1,IFLEX) | SS88681 |
| 960 FORMAT ('OTHER',I3,' NORMALIZED POINTS FOR THE FLEXIBILITY MATRIX ASSURE'//3(6X,1HX,10X,1HY,4X)/(/6F11.5)) | SS88682 |
| 970 CONTINUE | SS88683 |
| 9999 RETURN | SS88684 |
| 99999 CALL SKIPPR | SS88685 |
| GO TO 1 | SS88686 |
| END | SS88687 |
| | SS88688 |
| | SS88689 |

CC = 00690

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| C | SUBROUTINE CYLNDR (*) | SS8C000 |
| C | ** THIS SUBROUTINE CALCULATES THE NX, NY, AND NXY VALUES TO BE | SS8C001 |
| C | ** USED WHEN A SHELL IS LOADED BY AN AXIAL FORCE, A TORQUE, | SS8C002 |
| C | ** AND/OR A BENDING MOMENT. | SS8C003 |
| C | | SS8C004 |
| C | DIMENSION PX(10,10), PY(10,10), PXY(10,10), V(10) | SS8C005 |
| C | | SS8C006 |
| C | COMMON / GEOM / AA, BB, RR | SS8C007 |
| C | COMMON / NUMBER / NNUM(10), NPNX, NPNY | SS8C008 |
| C | COMMON / PARAM / PDUM(1650), PX, PY, PXY | SS8C009 |
| C | | SS8C010 |
| C | DATA V(1) / 1.00225 /, V(2) / .140605 /, V(3) / -23.2379 / | SS8C011 |
| C | DATA V(4) / 19.8787 /, V(5) / 28.8562 /, V(6) / -3.39401 / | SS8C012 |
| C | DATA V(7) / -25.2977 /, V(8) / -15.1520 /, V(9) / 16.6307 / | SS8C013 |
| C | DATA V(10) / 1.57479 / | SS8C014 |
| C | | SS8C015 |
| C | TORQUE = 0. | SS8C016 |
| C | PI = 3.1415926536 | SS8C017 |
| C | NPNX = 1 | SS8C018 |
| C | 5 FORMAT (1X) | SS8C019 |
| C | READ (5,5) FAXIAL, BNDMOM | SS8C020 |
| C | WRITE (6,6) FAXIAL, TORQUE, BNDMOM | SS8C021 |
| C | 6 FORMAT ('0THE APPLIED CYLINDER LOADS ARE --'/ | SS8C022 |
| C | 1 ' ',T40,'AXIAL FORCE =',E15.6,T74,'LBS.'/ | SS8C023 |
| C | 2 ' ',T40,'TORQUE =',E15.6,T74,'IN-LBS.'/ | SS8C024 |
| C | 3 ' ',T40,'BENDING MOMENT =',E15.6,T74,'IN-LBS.'/ | SS8C025 |
| C | PF = FAXIAL / 2. / PI / RR | SS8C026 |
| C | PT = TORQUE / 2. / PI / RR / RR | SS8C027 |
| C | PM = BNDMOM / PI / RR / RR | SS8C028 |
| C | IF (BNDMOM .GT. .0001) GO TO 10 | SS8C029 |
| C | NPNY = 1 | SS8C030 |
| C | PX (1,1) = PF | SS8C031 |
| C | PY (1,1) = 0. | SS8C032 |
| C | PXY(1,1) = PT | SS8C033 |
| C | RETURN 1 | SS8C034 |
| C | 10 NPNY = 10 | SS8C035 |
| C | DO 80 J=1,10 | SS8C036 |
| C | PX(1,J) = V(J)*PM | SS8C037 |
| C | PY(1,J) = 0. | SS8C038 |
| C | 80 PXY(1,J)= 0. | SS8C039 |
| C | PX(1,1) = PX(1,1) + PF | SS8C040 |
| C | PXY(1,1)= PT | SS8C041 |
| C | RETURN 1 | SS8C042 |
| C | END | SS8C043 |
| | | SS8C044 |

CC = 00045

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| SUBROUTINE CHECK (A) | SS8D000 |
| REAL*8 A | SS8D001 |
| COMMON / CHECKS / IERROR | SS8D002 |
| IERROR = 1 | SS8D003 |
| WRITE (6,6) A | SS8D004 |
| 6 FORMAT ('THE PROGRAM HAS READ AN UNACCEPTABLE VALUE FOR ',A6 / | SS8D005 |
| 1 ' THE NEXT PROBLEM WILL BE ATTEMPTED AFTER CHECKING THE CO | SS8D006 |
| 2NTROL VARIABLES') | SS8D007 |
| RETURN | SS8D008 |
| END | SS8D009 |

CC = 00010

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SUBROUTINE STIFF
C THIS SUBROUTINE CALCULATES THE 6 BY 6 ARRAY OF STIFFNESS TERMS AT SS8E000
C A POINT FOR A LAMINATED PLATE. THE INPUT IS THE NUMBER OF PLIES SS8E001
C (MPLY), THE ORIENTATIONS OF THE PLIES (TETA( )), THE THICKNESS OF SS8E002
C EACH PLY (THICK), AND THE MATERIAL PROPERTIES OF THE ORTHOTROPIC SS8E003
C PLIES (E1,E2,G, AND POISSON'S RATIO (U1)). SS8E004
C ** REVISED FOR CURVED PANELS - - 8/69 SS8E005
C DIMENSION AH(41), CB(3,3,40) SS8E006
C DIMENSION C1(40), C2(40), C3(40), C11(40), C22(40), C12(40) SS8E007
C COMMON / ABD / A(3,3), DS(3,3), DP(3,3), RHAB, TETA(40), SS8E008
1 THICK(40), E1(40), E2(40), G(40), U1(40), SS8E009
2 EC(3,40), ET(3,40), ANGCK(3,10), MCHK(3), AH SS8E010
COMMON / NUMBER / MPLY SS8E011
COMMON / CNTROL / IDUM(5), IMATL SS8E012
EQUIVALENCE (C1(1),E1(1)),(C2(1),E2(1)),(C3(1),U1(1)) SS8E013
C THE MIDDLE SURFACE IS LOCATED SS8E014
MPLY2= MPLY+1 SS8E015
AHK=0. SS8E016
DO 100 I=1, MPLY SS8E017
100 AHK= AHK + THICK(I)/2. SS8E018
AH(1)=-AHK SS8E019
DO 30 I=2, MPLY2 SS8E020
30 AH(I)= AH(I-1)+ THICK(I-1) SS8E021
C THE CBAR ARRAY IS CALCULATED FOR EACH PLY, USING DOUBLE-ANGLE SS8E022
C TRANSFORMATION FORMULAS. SS8E023
DO 40 N=1, MPLY SS8E024
U2= U1(N)*E2(N)/E1(N) SS8E025
DEL= 1.-U2*U1(N) SS8E026
CC1= E1(N)/DEL SS8E027
CC2= E2(N)/DEL SS8E028
CC3= CC1*U2 SS8E029
CC4= G(N) SS8E030
C11(N)= CC1 SS8E031
C22(N)= CC2 SS8E032
C12(N)= CC3 SS8E033
IF ( IMATL .EQ. 1 ) GO TO 40 SS8E034
COT = 2.*TETA(N)*.017453292519943 SS8E035
CO2= COS(COT) SS8E036
CO4= COS(2.*COT) SS8E037
SN2= SIN(COT) SS8E038
SN4= SIN(2.*COT) SS8E039
AJ1= CC1+CC2+2.*CC3 SS8E040
AJ2= CC4- CC3 SS8E041
CB(1,1,N)= .375*AJ1+.5*AJ2+(CC1-CC2)/2.*CO2+(AJ1/8.+AJ2/2.-CC4)*CO4 SS8E042
CB(1,2,N)=AJ1/8. -AJ2/2.+(CC4-AJ1/8.-AJ2/2.)*CO4 SS8E043
CB(2,1,N)= CB(1,2,N) SS8E044
CB(1,3,N)=(CC1- CC2)/4.*SN2 +(AJ1/8.+AJ2/2.- CC4)*SN4 SS8E045
CB(3,1,N)=CB(1,3,N) SS8E046
CB(2,2,N)= CB(1,1,N) +(CC2-CC1)*CO2 SS8E047
CB(2,3,N)= CB(1,3,N) -(AJ1/4.+AJ2-CC4*2.)*SN4 SS8E048
CB(3,2,N)= CB(2,3,N) SS8E049
CB(3,3,N)= AJ1/8. +AJ2/2. +(CC4 -AJ1/8.-AJ2/2.)*CO4 SS8E050
40 CONTINUE SS8E051
C THE A, DSTAR, AND D MATRICES ARE CALCULATED AND STORED IN A( , ), SS8E052
C DS( , ), AND DP( , ). SS8E053
IF ( IMATL .EQ. 1 ) GO TO 51 SS8E054
SS8E055

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| | |
|---|---------|
| DO 50 I=1,3 | SS8E056 |
| DO 50 J=1,3 | SS8E057 |
| A(I,J)=0. | SS8E058 |
| DS(I,J)=0. | SS8E059 |
| DP(I,J)=0. | SS8E060 |
| AX=AH(1)*AH(1) | SS8E061 |
| DO 60 K=1,MPLY | SS8E062 |
| A(I,J)=A(I,J)+ CB(I,J,K) *(AH(K+1)-AH(K)) | SS8E063 |
| AY=AX | SS8E064 |
| AX=AH(K+1)*AH(K+1) | SS8E065 |
| DP(I,J)= DP(I,J)+ CB(I,J,K)*(AX*AH(K+1)-AY*AH(K)) | SS8E066 |
| 60 DS(I,J)= DS(I,J)+ CB(I,J,K)*(AX-AY) | SS8E067 |
| DP(I,J)=DP(I,J)/3. | SS8E068 |
| DS(I,J)= DS(I,J)/2. | SS8E069 |
| DP(J,I)= DP(I,J) | SS8E070 |
| DS(J,I)= DS(I,J) | SS8E071 |
| 50 A(J,I)= A(I,J) | SS8E072 |
| 51 CONTINUE | SS8E073 |
| DO 70 N=1,MPLY | SS8E074 |
| C1(N) = C11(N) | SS8E075 |
| C2(N) = C22(N) | SS8E076 |
| 70 C3(N) = C12(N) | SS8E077 |
| RETURN | SS8E078 |
| END | SS8E079 |

CC = 00080

| | | |
|------|---|---------|
| | SUBROUTINE TABLE | SS8F000 |
| C | | SS8F001 |
| C ** | THIS SUBROUTINE SERVES AS A CONTROL PROGRAM FOR THE CALCULATION | SS8F002 |
| C ** | OF THE TABLE OF INTEGRALS. | SS8F003 |
| C | | SS8F004 |
| | DIMENSION AL(1,2,6,3,10,3,10), EVAL(4,2,3,10,25), TIME(50), | SS8F005 |
| 1 | \$W(10,2,3,10,10), P(11,2,3,3,10), ITIME(12) | SS8F006 |
| C | | SS8F007 |
| | COMMON / ARRAYS / P, AL, \$W | SS8F008 |
| | COMMON / VALUES / EVAL | SS8F009 |
| | COMMON / NUMBER / N1, NTUX, NTVX, NTWX, NTUY, | SS8F010 |
| 1 | NTVY, NTWY, NMODES, NSTRNG, NRING, | SS8F011 |
| 2 | NPNX, NPNY, NQTX, NQTY, N\$(9), | SS8F012 |
| 3 | ITX, ITY | SS8F013 |
| | COMMON / CNTROL / N3(3), IBCX, IBCY, N4(7), INTPRT | SS8F014 |
| | COMMON / GEOM / ADUM(3), ALFAX, ALFAY, BETAX, BETAY | SS8F015 |
| | COMMON / \$TIME / TIME, ITIME | SS8F016 |
| C | | SS8F017 |
| | CALL STATUS (ITIME) | SS8F018 |
| | TIME(3) = ITIME(8)/100. | SS8F019 |
| | ET = TIME(3) - TIME(1) | SS8F020 |
| | IF (INTPRT .EQ. 1) WRITE (6,10) ET | SS8F021 |
| 10 | FORMAT ('OELAPSED TIME BEFORE TABLE GENERATION = 'F7.3) | SS8F022 |
| | MAX\$X = MAXO (NPNX, NQTX, 1) | SS8F023 |
| | MAX\$Y = MAXO (NPNY, NQTY, 1) | SS8F024 |
| | MAX\$XY = MAXO (MAX\$X, MAX\$Y) | SS8F025 |
| | MAXP1 = MAX\$XY + 1 | SS8F026 |
| C | | SS8F027 |
| | JBCX = IBCX | SS8F028 |
| | JBCY = IBCY | SS8F029 |
| | CALL INTEGL (ALFAX, BETAX, JBCX, NTUX, MAX\$X, 1, ITX) | SS8F030 |
| | CALL INTEGL (ALFAY, BETAY, JBCY, NTUY, MAX\$Y, 2, ITY) | SS8F031 |
| C | | SS8F032 |
| 190 | CALL STATUS (ITIME) | SS8F033 |
| | TIME(4) = ITIME(8)/100. | SS8F034 |
| | ET = TIME(4) - TIME(3) | SS8F035 |
| | IF (INTPRT .EQ. 1) WRITE (6,200) ET | SS8F036 |
| 200 | FORMAT ('OINTEGRAL EVALUATION TIME = 'F7.3) | SS8F037 |
| | RETURN | SS8F038 |
| | END | SS8F039 |

CC = 00040

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C      SUBROUTINE INTEGL ($ALFA,$BETA,MNIJ,NTERMS,IPOWER,IDEFNE,IZ)      SS8G000
C      THIS SUBROUTINE COMPUTES AND RETURNS, WITH THE AID OF 'PPP',      SS8G001
C      'SPECIAL', AND ELASTC, THE INTEGRALS AND MODE SHAPE EVALUATIONS FORSS8G002
C      ANY OF THE BEAM CONDITIONS CONSIDERED. THE INPUT IS $ALFA, $BETA,SS8G003
C      AND MNIJ. $ALFA,$BETA ARE USED IN SUBROUTINE ELASTC IF AND ONLY      SS8G004
C      IF MNIJ IS GREATER THAN 6. IF MNIJ IS LESS THAN 7, THE INITIAL      SS8G005
C      FREQUENCY ESTIMATES ARE READ INTO EPI ). THESE ESTIMATES ARE USEDSS8G006
C      WITH A NEWTON-RAPHSON ITERATION ON THE APPROPRIATE FREQUENCY      SS8G007
C      EQUATION TO OBTAIN ACCURATE FREQUENCIES AND MODE SHAPES. THE      SS8G008
C      RESULTS ARE RETURNED THROUGH THE COMMON BLOCK ARRAYS. THE ROUTINE      SS8G009
C      IS IN DOUBLE PRECISION .      SS8G010
C ** REVISED FOR CURVED PANELS - - 8/69      SS8G011
C      IMPLICIT REAL*8(A-H,O-Z), INTEGER (I-N)      SS8G012
C      DIMENSION C(4,4,3,10),CLASTC(4,10),FFF(10)      SS8G013
C      COMMON / BLOCK /      AL(1,6,3,10,3,10), EVAL(4,3,10,25),      SS8G014
1      EVQ(4,3,2,25),      PZ(11,3,3,10),      SS8G015
2      TH(10,4,4,3),      ALVA(11,11,2),      P(11,10),      SS8G016
3      CE(4,10), E(4,4), EP(10), CN(4), CM(4)      SS8G017
C      COMMON / ARRAYS / $P(11,2,3,3,10), $AL(1,2,6,3,10,3,10),      SS8G018
1      $W(10,2,3,10,10)      SS8G019
C      COMMON / VALUES / $EVAL(4,2,3,10,25)      SS8G020
C      COMMON / NUMBER / NDUM(8), NSTRNG, NRING      SS8G021
C      COMMON / STFVAL / $ESV(10,100), $ESW(10,100), $ESDW(10,100),      SS8G022
1      $ERU(10,50), $ERW(10,50), $ERDW(10,50),      SS8G023
2      $STRNG(100), $RINGS(50)      SS8G024
C      COMMON / CNTROL / IFLAGD, IFLAGB      SS8G025
C      MNIJ IS A FLAG FOR BOUNDARY CONDITION      SS8G026
C      MNIJ = 0 FOR FULL CYLINDER      SS8G027
C      MNIJ=1 FOR FIXED SIMPLE BEAM, =2 FOR SIMPLE-SIMPLE, =3 FOR FIXED-      SS8G028
C      FIXED, =4 FOR FIXED-FREE, =5 FOR SIMPLE FREE, AND = 6 FOR FREE-      SS8G029
C      FREE. GREATER THAN 6 IS USED FOR ELASTICALLY RESTRAINED.      SS8G030
C      PIE = 3.1415926535898      SS8G031
C      S3 = DSQRT (3.00)      SS8G032
C      IF(MNIJ .GT. 6) GO TO 700      SS8G033
C      ASH= 0 ,IJKLM=-1,IKJ=1 FOR A SIMPLE-SIMPLE BEAM      SS8G034
C      ASH=-1.,IJKLM= 0,IKJ=1 FOR A FIXED-FIXED BEAM      SS8G035
C      ASH=-1.,IJKLM=+1,IKJ=3 FOR A FREE-FREE BEAM      SS8G036
C      ASH=+1.,IJKLM= 0,IKJ=1 FOR A FIXED-FREE BEAM      SS8G037
C      ASH= 0 ,IJKLM=-2,IKJ=2 FOR A SIMPLE-FREE BEAM      SS8G038
C      ASH= 0 ,IJKLM=-3,IKJ=1 FOR A FIXED-SIMPLE BEAM      SS8G039
C      ICYL=0      SS8G040
C      IF(MNIJ.NE.0) GO TO 2999      SS8G041
C      CYLINDER      SS8G042
C      ICYL=1      SS8G043
C      ASH = 0.      SS8G044
C      IJKLM = -1      SS8G045
C      IKJ = 1      SS8G046
C      I500 = 2      SS8G047
C      IF ( IFLAGB .NE. 0 ) GO TO 2997      SS8G048
C      EP(1) = IZ * 6.28319      SS8G049
C      DO 3000 I=2,NTERMS      SS8G050
3000 EP(I) = EP(I-1) + 6.283      SS8G051
C      GO TO 3009      SS8G052
C      2997 EP(1) = IZ * 3.14159      SS8G053
C      DO 2998 I=2,NTERMS      SS8G054
2998 EP(I) = EP(I-1) + 3.14159      SS8G055

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| | GO TO 3009 | SS8G056 |
| 2999 | IF(MNIJ.NE.1) GO TO 3001 | SS8G057 |
| C | CLAMPED - SIMPLE | SS8G058 |
| | ASH=0. | SS8G059 |
| | IJKLM= -3 | SS8G060 |
| | IKJ = 1 | SS8G061 |
| | $EP(1) = (4.*IZ + 1.) * PIE / 4.$ | SS8G062 |
| | GO TO 3007 | SS8G063 |
| 3001 | IF(MNIJ.NE.2)GO TO 3002 | SS8G064 |
| C | SIMPLE - SIMPLE | SS8G065 |
| | ASH=0. | SS8G066 |
| | IJKLM=-1 | SS8G067 |
| | IKJ=1 | SS8G068 |
| | $EP(1) = IZ * 3.14159$ | SS8G069 |
| | GO TO 3007 | SS8G070 |
| 3002 | IF(MNIJ.NE.3)GO TO 3003 | SS8G071 |
| C | CLAMPED - CLAMPED | SS8G072 |
| | ASH=-1. | SS8G073 |
| | IJKLM=0 | SS8G074 |
| | IKJ=1 | SS8G075 |
| | $EP(1) = (2.*IZ + 1.) * PIE / 2.$ | SS8G076 |
| | GO TO 3007 | SS8G077 |
| 3003 | IF(MNIJ.NE.4) GO TO 3004 | SS8G078 |
| C | CLAMPED - FREE | SS8G079 |
| | ASH=1. | SS8G080 |
| | IJKLM=0 | SS8G081 |
| | IKJ=1 | SS8G082 |
| | $EP(1) = (2.*IZ - 1.) * PIE / 2.$ | SS8G083 |
| | GO TO 3007 | SS8G084 |
| 3004 | IF(MNIJ.NE.5)GO TO 3005 | SS8G085 |
| C | SIMPLE - FREE | SS8G086 |
| | ASH=0. | SS8G087 |
| | IJKLM=-2 | SS8G088 |
| | IF (IZ .NE. 1) GO TO 3105 | SS8G089 |
| | IKJ= 2 | SS8G090 |
| | EP(1)= 3. | SS8G091 |
| | EP(2)= 3.93 | SS8G092 |
| | GO TO 3007 | SS8G093 |
| 3105 | IKJ = 1 | SS8G094 |
| | $EP(1) = (4.*IZ - 3.) * PIE / 4.$ | SS8G095 |
| | GO TO 3007 | SS8G096 |
| 3005 | ASH= -1. | SS8G097 |
| C | FREE - FREE | SS8G098 |
| | IJKLM= 1 | SS8G099 |
| | IF (IZ .NE. 0) GO TO 3100 | SS8G100 |
| | IKJ=3 | SS8G101 |
| | EP(1)=3. | SS8G102 |
| | EP(2)=2. | SS8G103 |
| | EP(3)=4.73 | SS8G104 |
| | GO TO 3007 | SS8G105 |
| 3100 | IKJ = 1 | SS8G106 |
| | $EP(1) = (2.*IZ - 1.) * PIE / 2.$ | SS8G107 |
| 3007 | I500=IKJ+1 | SS8G108 |
| | DO 3008 I=I500,NTERMS | SS8G109 |
| 3008 | EP(I) = EP(I-1)+3.142 | SS8G110 |
| C | COMPUTE ACCURATE FREQUENCIES FROM HERE TO 200 | SS8G111 |

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| 3009 | CONTINUE | SS8G112 |
| | DO 200 I=IKJ, NTERMS | SS8G113 |
| | DO 200 J=1, 8 | SS8G114 |
| | DC=DCOS(EP(I)) | SS8G115 |
| | DS=DSIN(EP(I)) | SS8G116 |
| | DX=DEXP(EP(I)) | SS8G117 |
| | DCH=.5*(DX+1./DX) | SS8G118 |
| | DSH=.5*(DX-1./DX) | SS8G119 |
| | IF(IJKLM.LT.0) GO TO 450 | SS8G120 |
| | FX=DC*DCH+ASH | SS8G121 |
| | FPX=-DS*DCH+DC*DSH | SS8G122 |
| | GO TO 451 | SS8G123 |
| 450 | IF(IJKLM.EQ.-1)GO TO 452 | SS8G124 |
| | FX=DS/DC - DSH/DCH | SS8G125 |
| | FPX=1./DC/DC -1./DCH/DCH | SS8G126 |
| | GO TO 451 | SS8G127 |
| 452 | FX= DS | SS8G128 |
| | FPX=DC | SS8G129 |
| 451 | CONTINUE | SS8G130 |
| | EP(I)=EP(I)-FX/FPX | SS8G131 |
| 200 | CONTINUE | SS8G132 |
| C | COMPUTE MODE SHAPE CONSTANTS FROM HERE TO 1 | SS8G133 |
| | DO 1 N=1, NTERMS | SS8G134 |
| | SN=DSIN(EP(N)) | SS8G135 |
| | CS=DCOS(EP(N)) | SS8G136 |
| | DX=DEXP(EP(N)) | SS8G137 |
| | SH=.5*(DX-1./DX) | SS8G138 |
| | CH=.5*(DX+1./DX) | SS8G139 |
| | IF(ICYL.EQ.1) GO TO 9450 | SS8G140 |
| | IF(IJKLM.LT.0)GO TO 460 | SS8G141 |
| | IF(IJKLM.GT.0) GO TO 351 | SS8G142 |
| C | CLAMPED - CLAMPED | SS8G143 |
| C | CLAMPED - FREE | SS8G144 |
| | C(1,4,3,N)=(CH*ASH+CS)/(SN*ASH+SH)*ASH | SS8G145 |
| | C(1,3,3,N)=-C(1,4,3,N) | SS8G146 |
| | C(1,1,3,N)= 1. | SS8G147 |
| | C(1,2,3,N)= -1. | SS8G148 |
| | GO TO 1 | SS8G149 |
| C | FREE - FREE | SS8G150 |
| 351 | C(1,1,3,N)= 1. | SS8G151 |
| | C(1,2,3,N)= 1. | SS8G152 |
| | C(1,3,3,N)= (-CS+CH)/(SN-SH) | SS8G153 |
| | C(1,4,3,N)= C(1,3,3,N) | SS8G154 |
| | GO TO 1 | SS8G155 |
| 9450 | C(1,2,3,N)= DSQRT(2.DO) | SS8G156 |
| | C(1,1,3,N)= 0. | SS8G157 |
| | C(1,3,3,N)= 0. | SS8G158 |
| | C(1,4,3,N)= 0. | SS8G159 |
| | GO TO 1 | SS8G160 |
| 460 | IF(IJKLM .EQ.-1) GO TO 453 | SS8G161 |
| | IF(IJKLM.EQ.-2)GO TO 454 | SS8G162 |
| C | CLAMPED - SIMPLE | SS8G163 |
| | C(1,1,3,N)= 1. | SS8G164 |
| | C(1,2,3,N)= -1. | SS8G165 |
| | C(1,3,3,N)= (CS-CH)/(SH-SN) | SS8G166 |
| | C(1,4,3,N)= -C(1,3,3,N) | SS8G167 |

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| | GO TO 1 | SS8G168 |
| C | SIMPLE - FREE | SS8G169 |
| 454 | C(1,1,3,N)= 0. | SS8G170 |
| | C(1,2,3,N)= 0. | SS8G171 |
| | C(1,4,3,N)= 2.*SH/(-SN+SH) | SS8G172 |
| | C(1,3,3,N)= C(1,4,3,N)-2.DO | SS8G173 |
| | AV= DSQRT(C(1,4,3,N) + C(1,3,3,N)) | SS8G174 |
| | C(1,4,3,N)= C(1,4,3,N)/AV | SS8G175 |
| | C(1,3,3,N)= C(1,3,3,N)/AV | SS8G176 |
| | GO TO 1 | SS8G177 |
| C | SIMPLE - SIMPLE | SS8G178 |
| 453 | C(1,1,3,N)= 0. | SS8G179 |
| | C(1,2,3,N)= 0. | SS8G180 |
| | C(1,3,3,N)= 0. | SS8G181 |
| | C(1,4,3,N)= DSQRT(2.DO) | SS8G182 |
| | 1 CONTINUE | SS8G183 |
| | GO TO 701 | SS8G184 |
| C | ELASTIC RESTRAINT | SS8G185 |
| 700 | ALFA= \$ALFA | SS8G186 |
| | BETA= \$BETA | SS8G187 |
| C | FREQUENCIES AND SHAPE COEFFICIENTS ARE COMPUTED IN ELASTC. | SS8G188 |
| | CALL ELASTC (CLASTC,ALFA,BETA,NTERMS) | SS8G189 |
| | DO 7000 J=1,4 | SS8G190 |
| | DO 7000 N=1,NTERMS | SS8G191 |
| 7000 | C(1,J,3,N) = CLASTC(J,N) | SS8G192 |
| 701 | CONTINUE | SS8G193 |
| C | THE COEFFICIENTS OF THE 'NORMALIZED' DERIVATIVES ARE PUT IN C() | SS8G194 |
| | INIJ= MNIJ | SS8G195 |
| | MNIJ= IDEFNE | SS8G196 |
| | ID=IDEFNE | SS8G197 |
| | DO 2 N=1,NTERMS | SS8G198 |
| | C(2,1,3,N)= C(1,3,3,N) | SS8G199 |
| | C(2,2,3,N)= C(1,4,3,N) | SS8G200 |
| | C(2,3,3,N)= C(1,1,3,N) | SS8G201 |
| | C(2,4,3,N)=-C(1,2,3,N) | SS8G202 |
| | C(3,1,3,N)= C(1,1,3,N) | SS8G203 |
| | C(3,2,3,N)=-C(1,2,3,N) | SS8G204 |
| | C(3,3,3,N)= C(1,3,3,N) | SS8G205 |
| 2 | C(3,4,3,N)=-C(1,4,3,N) | SS8G206 |
| | IF(IDEFNE.EQ.2) GO TO 9910 | SS8G207 |
| | DO 9900 I=1,4 | SS8G208 |
| | DO 9900 N=1,NTERMS | SS8G209 |
| | C(1,I,1,N) = C(2,I,3,N) * EP(N) | SS8G210 |
| 9900 | C(1,I,2,N)=C(1,I,3,N) | SS8G211 |
| | GO TO 9920 | SS8G212 |
| 9910 | DO 9915 I=1,4 | SS8G213 |
| | DO 9915 N=1,NTERMS | SS8G214 |
| | C(1,I,1,N)=C(1,I,3,N) | SS8G215 |
| 9915 | C(1,I,2,N) = C(2,I,3,N) * EP(N) | SS8G216 |
| 9920 | DO 9930 I=1,2 | SS8G217 |
| | DO 9930 N=1,NTERMS | SS8G218 |
| | C(2,1,I,N)= C(1,3,I,N) | SS8G219 |
| | C(2,2,I,N)= C(1,4,I,N) | SS8G220 |
| | C(2,3,I,N)= C(1,1,I,N) | SS8G221 |
| | C(2,4,I,N)=-C(1,2,I,N) | SS8G222 |
| | C(3,1,I,N)= C(1,1,I,N) | SS8G223 |

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| C(3,2,I,N)=-C(1,2,I,N) | SS8G224 |
| C(3,3,I,N)= C(1,3,I,N) | SS8G225 |
| 9930 C(3,4,I,N)=-C(1,4,I,N) | SS8G226 |
| C FACTORIAL GENERATION | SS8G227 |
| IPOWER = IPOWER+1 | SS8G228 |
| DO 2001 I=1,IPOWER | SS8G229 |
| DO 2002 L=1,I | SS8G230 |
| ALVA(I,L,2)=0. | SS8G231 |
| J=I-1 | SS8G232 |
| K=I-L | SS8G233 |
| DFAC = 1. | SS8G234 |
| FAC=1. | SS8G235 |
| IF(J.LE.1)GO TO 2003 | SS8G236 |
| DO 2004 JJ=2,J | SS8G237 |
| AMTP= JJ | SS8G238 |
| 2004 FAC= FAC*AMTP | SS8G239 |
| 2003 IF(K.LE.1)GO TO 2005 | SS8G240 |
| DO 2006 KK=2,K | SS8G241 |
| AMTP= KK | SS8G242 |
| 2006 DFAC = AMTP*DFAC | SS8G243 |
| 2005 ALVA(I,L,1)= ((-1.)**(L+1))*FAC/DFAC | SS8G244 |
| 2002 CONTINUE | SS8G245 |
| 2001 ALVA(I,I,2)=ALVA(I,I,1) | SS8G246 |
| PI=3.1415926535898/2. | SS8G247 |
| DO 1001 IUVW=1,3 | SS8G248 |
| DO 1001 JUVW=1,3 | SS8G249 |
| DO 1001 M=1,NTERMS | SS8G250 |
| EPM = EP(M) | SS8G251 |
| DO 1001 N=1,NTERMS | SS8G252 |
| EPN= EP(N) | SS8G253 |
| OMEGA1= EPM+ EPN | SS8G254 |
| OMEGA2= EPN- EPM | SS8G255 |
| EX1= .25*DEXP(OMEGA1) | SS8G256 |
| EMX1=1./EX1/16. | SS8G257 |
| EX2 =.25*DEXP(OMEGA2) | SS8G258 |
| EMX2=1./EX2/16. | SS8G259 |
| SN1 = DSIN(OMEGA1)/2. | SS8G260 |
| SN2 = DSIN(OMEGA2)/2. | SS8G261 |
| CS1=DCOS(OMEGA1)/2. | SS8G262 |
| CS2=DCOS(OMEGA2)/2. | SS8G263 |
| FACTOR=1. | SS8G264 |
| DO 1002 I=1,IPOWER | SS8G265 |
| FACTOR= FACTOR*I | SS8G266 |
| O1I = (OMEGA1)**I | SS8G267 |
| FFF(I) = EX1/O1I | SS8G268 |
| T111= 0.0 | SS8G269 |
| T112= ((-1.)**I)*EMX1/O1I | SS8G270 |
| T113= (1.-(-1.)**(I+1))/2./O1I /2. | SS8G271 |
| 1003 T121=0. | SS8G272 |
| T122=(DSIN(I*PI)*SN1 +DCOS(I*PI)*CS1)/O1I | SS8G273 |
| T123= DCOS(I*PI)/2./O1I | SS8G274 |
| IF(M.EQ.N) GO TO 1004 | SS8G275 |
| O2I= (OMEGA2)**I | SS8G276 |
| T211= EX2/O2I | SS8G277 |
| T212= ((-1.)**I)*EMX2/O2I | SS8G278 |
| T213= (1.-(-1.)**(I+1))/4./O2I | SS8G279 |

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| | IF(DABS(T211).GE. DABS(T212)) GO TO 1005 | SS8G280 |
| | TX15= T211 | SS8G281 |
| | T211= T212 | SS8G282 |
| | T212= TX15 | SS8G283 |
| 1005 | T221= 0. | SS8G284 |
| | T222= (DSIN(I*PI)*SN2 + DCOS(I*PI)*CS2)/O2I | SS8G285 |
| | T223= DCOS(I*PI)/2./O2I | SS8G286 |
| | GO TO 1006 | SS8G287 |
| 1004 | T211= 0. | SS8G288 |
| | T221= 0. | SS8G289 |
| | T212= .5/FACTOR | SS8G290 |
| | T222= T212 | SS8G291 |
| | T213=0. | SS8G292 |
| | T223= 0. | SS8G293 |
| 1006 | TH(I,1,1,1) = T111 + T211 | SS8G294 |
| | TH(I,1,1,2) = T112 + T212 | SS8G295 |
| | TH(I,2,2,1) = T121 + T221 | SS8G296 |
| | TH(I,2,2,2) = T122 + T222 | SS8G297 |
| | TH(I,3,3,1) = T111 - T211 | SS8G298 |
| | TH(I,3,3,2) = T112 - T212 | SS8G299 |
| | TH(I,4,4,1) =-T121 + T221 | SS8G300 |
| | TH(I,4,4,2) =-T122 + T222 | SS8G301 |
| | TH(I,1,1,3) = T113 + T213 | SS8G302 |
| | TH(I,2,2,3) = T123 + T223 | SS8G303 |
| | TH(I,3,3,3) = T113 - T213 | SS8G304 |
| 1002 | TH(I,4,4,3) =-T123 + T223 | SS8G305 |
| | IFLAG= -1 | SS8G306 |
| 1007 | EPSAVE = EPN | SS8G307 |
| | EPN = EPM | SS8G308 |
| | EPM = EPSAVE | SS8G309 |
| | OMEGA1 =EPM+EPN | SS8G310 |
| | OMEGA2 =EPN-EPM | SS8G311 |
| | EX1= .25*DEXP(OMEGA1) | SS8G312 |
| | EMX1= 1./EX1/16. | SS8G313 |
| | EX2 = DEXP(OMEGA2)/4. | SS8G314 |
| | EMX2= 1./EX2/16. | SS8G315 |
| | SN1= DSIN(OMEGA1)/2. | SS8G316 |
| | SN2= DSIN(OMEGA2)/2. | SS8G317 |
| | CS1= DCOS(OMEGA1)/2. | SS8G318 |
| | CS2= DCOS(OMEGA2)/2. | SS8G319 |
| | DELO= EPM*EPM+ EPN*EPN | SS8G320 |
| | DELI1= 1. | SS8G321 |
| | DELI2= 0. | SS8G322 |
| | EPEPN = DEXP(EPN)/2. | SS8G323 |
| | EMEPN = 1./EPEPN/4. | SS8G324 |
| | SNEPM= DSIN(EPM) | SS8G325 |
| | CSEPM= DCOS(EPM) | SS8G326 |
| | DO 1008 I=1,IPOWER | SS8G327 |
| | DELI1S = EPN*DELI1 - EPM*DELI2 | SS8G328 |
| | DELI2 = EPM*DELI1 + EPN*DELI2 | SS8G329 |
| | DELI1 = DELI1S | SS8G330 |
| | O1I = (OMEGA1)**I | SS8G331 |
| | DELOI =(DELO)**I | SS8G332 |
| | TH(I,3,1,1) = 0.0 | SS8G333 |
| | TH(I,3,1,2)=((-1.)**(I+1))*EMX1/O1I | SS8G334 |
| | TH(I,3,1,3)= (1.-(-1.)**I)/2./O1I/2. | SS8G335 |

| | |
|---|---------|
| TH(I,4,2,1) = 0. | SS8G336 |
| TH(I,4,2,2) = (-DSIN(I*PI)*CS1 +DCOS(I*PI)*SN1)/O1I | SS8G337 |
| TH(I,4,2,3) = -DSIN(I*PI)/2./O1I | SS8G338 |
| TH(I,1,2,1) = EPEPN/DELOI*(DELI1*CSEPM + DELI2*SNEPM) | SS8G339 |
| TH(I,1,2,2) = EMEPN/DELOI*((-1.)*I)*DELI1*CSEPM | SS8G340 |
| 1 +((-1.)*I)*DELI2*SNEPM) | SS8G341 |
| TH(I,1,2,3) = DELI1/2./DELOI*(1.+(-1.)*I) | SS8G342 |
| TH(I,3,2,3) = DELI1/2./DELOI*(1.-(-1.)*I) | SS8G343 |
| TH(I,3,2,1) = TH(I,1,2,1) | SS8G344 |
| TH(I,3,2,2) = -TH(I,1,2,2) | SS8G345 |
| TH(I,1,4,1) = EPEPN/DELOI*(DELI1*SNEPM -DELI2*CSEPM) | SS8G346 |
| TH(I,1,4,2) = EMEPN/DELOI*((-1.)*I)*DELI2*CSEPM | SS8G347 |
| 1 +((-1.)*I)*DELI1*SNEPM) | SS8G348 |
| TH(I,1,4,3) = DELI2/2./DELOI*(-1.+(-1.)*I) | SS8G349 |
| TH(I,3,4,3) = DELI2/2./DELOI*(-1.-(-1.)*I) | SS8G350 |
| TH(I,3,4,1) = TH(I,1,4,1) | SS8G351 |
| TH(I,3,4,2) = -TH(I,1,4,2) | SS8G352 |
| IF(M.EQ.N) GO TO 1009 | SS8G353 |
| O2I=(OMEGA2)**I | SS8G354 |
| TBIG =EX2/O2I | SS8G355 |
| TSMALL= ((-1.)*I)*EMX2/O2I | SS8G356 |
| TH(I,3,1,3) = TH(I,3,1,3) + (1.-(-1.)*I)/2./O2I/2. | SS8G357 |
| TH(I,4,2,2) = TH(I,4,2,2)+ (-DSIN(I*PI)*CS2+DCOS(I*PI)*SN2)/O2I | SS8G358 |
| TH(I,4,2,3) = TH(I,4,2,3) -DSIN(I*PI)/2./O2I | SS8G359 |
| IF(DABS(TBIG).GE.DABS(TSMALL))GO TO 1010 | SS8G360 |
| TX15 =TBIG | SS8G361 |
| TBIG = TSMALL | SS8G362 |
| TSMALL = TX15 | SS8G363 |
| 1010 TH(I,3,1,1) = TH(I,3,1,1) + TBIG | SS8G364 |
| TH(I,3,1,2) = TH(I,3,1,2) + TSMALL | SS8G365 |
| 1009 CONTINUE | SS8G366 |
| 1008 CONTINUE | SS8G367 |
| IF(IFLAG.GT. 0) GO TO 1011 | SS8G368 |
| IFLAG = +1 | SS8G369 |
| DO 1012 I=1, IPOWER | SS8G370 |
| DO 1012 J=1,3 | SS8G371 |
| TH(I,1,3,J) = TH(I,3,1,J) | SS8G372 |
| TH(I,2,4,J) = TH(I,4,2,J) | SS8G373 |
| TH(I,2,1,J) = TH(I,1,2,J) | SS8G374 |
| TH(I,2,3,J) = TH(I,3,2,J) | SS8G375 |
| TH(I,4,1,J) = TH(I,1,4,J) | SS8G376 |
| 1012 TH(I,4,3,J) = TH(I,3,4,J) | SS8G377 |
| GO TO 1007 | SS8G378 |
| 1011 CONTINUE | SS8G379 |
| C TH(I,K,J) ARE NOW STORED | SS8G380 |
| DO 1001 K=1,6 | SS8G381 |
| IF(K-2)25,26,27 | SS8G382 |
| 27 IF(K-4)28,29,30 | SS8G383 |
| 30 IF(K-6)31,32,32 | SS8G384 |
| 25 NN=1 | SS8G385 |
| MM=1 | SS8G386 |
| GO TO 6 | SS8G387 |
| 26 NN=2 | SS8G388 |
| MM=2 | SS8G389 |
| GO TO 6 | SS8G390 |
| 28 NN=3 | SS8G391 |

| | | |
|------|--|---------|
| | MM=3 | SS8G392 |
| | GO TO 6 | SS8G393 |
| 29 | NN=2 | SS8G394 |
| | MM=1 | SS8G395 |
| | GO TO 6 | SS8G396 |
| 31 | NN=3 | SS8G397 |
| | MM=1 | SS8G398 |
| | GO TO 6 | SS8G399 |
| 32 | NN=3 | SS8G400 |
| | MM=2 | SS8G401 |
| 6 | DO 7 J=1,4 | SS8G402 |
| | CN(J)=C(NN,J,IUVW,N) | SS8G403 |
| 7 | CM(J)=C(MM,J,JUVW,M) | SS8G404 |
| | EXYZ = (EPN**((NN-1)))*(EPM**((MM-1))) | SS8G405 |
| | DO 8 J=1,4 | SS8G406 |
| | DO 8 I=1,4 | SS8G407 |
| 8 | E(J,I)= CN(J)*CM(I)*EXYZ | SS8G408 |
| | SAVEIT= (CN(1)+CN(3))*(CM(1)+CM(3))*EXYZ | SS8G409 |
| | I = 1 | SS8G410 |
| | AL(I,K,IUVW,N,JUVW,M)=0. | SS8G411 |
| | SAVE1= 0. | SS8G412 |
| | SAVE2= 0. | SS8G413 |
| | SAVE3= 0. | SS8G414 |
| | SAVE4=0. | SS8G415 |
| | DO 1114 L=1,I | SS8G416 |
| | SAVE1 = SAVE1 + SAVEIT*ALVA(I,L,1)*FFF(L) | SS8G417 |
| | DO 1114 IT=1,4 | SS8G418 |
| | DO 1114 IU=1,4 | SS8G419 |
| | SAVE4= SAVE4 + E(IT,IU)*ALVA(I,L,1)*TH(L,IT,IU,1) | SS8G420 |
| | SAVE2= SAVE2 + E(IT,IU)*ALVA(I,L,1)*TH(L,IT,IU,2) | SS8G421 |
| 1114 | SAVE3= SAVE3 + E(IT,IU)*ALVA(I,L,2)*TH(L,IT,IU,3) | SS8G422 |
| 1014 | AL(I,K,IUVW,N,JUVW,M)= SAVE1 + SAVE2 - SAVE3 + SAVE4 | SS8G423 |
| | IF (K .LE. 2) KK=K | SS8G424 |
| | IF (K .EQ. 3) GO TO 1001 | SS8G425 |
| | IF (K .EQ. 4) KK=3 | SS8G426 |
| | IF (K .GE. 5) GO TO 1001 | SS8G427 |
| | IF(IUVW.NE.3) GO TO 1001 | SS8G428 |
| | IF(JUVW.NE.3) GO TO 1001 | SS8G429 |
| | DO 6000 I=1,IPOWER | SS8G430 |
| | \$W(I,ID,KK,N,M) = 0. | SS8G431 |
| | SAVE1 = 0. | SS8G432 |
| | SAVE2 = 0. | SS8G433 |
| | SAVE3 = 0. | SS8G434 |
| | SAVE4 = 0. | SS8G435 |
| | DO 5000 L=1,I | SS8G436 |
| | SAVE1 = SAVE1 + SAVEIT * ALVA(I,L,1) * FFF(L) | SS8G437 |
| | DO 5000 IT=1,4 | SS8G438 |
| | DO 5000 IU=1,4 | SS8G439 |
| | SAVE4 = SAVE4 + E(IT,IU) * ALVA(I,L,1) * TH(L,IT,IU,1) | SS8G440 |
| | SAVE2= SAVE2 + E(IT,IU) * ALVA(I,L,1) * TH(L,IT,IU,2) | SS8G441 |
| 5000 | SAVE3 = SAVE3 + E(IT,IU) * ALVA(I,L,2) * TH(L,IT,IU,3) | SS8G442 |
| 6000 | \$W(I,ID,KK,N,M) = SAVE1 + SAVE2 - SAVE3 + SAVE4 | SS8G443 |
| 1001 | CONTINUE | SS8G444 |
| C | THE P INTEGRALS ARE NOW EVALUATED, AND ALSO ANY SPECIAL CASES. | SS8G445 |
| | IPO2= IPOWER+1 | SS8G446 |
| | IN = 1 | SS8G447 |

| | | |
|---|---------------|---------|
| IF (INIJ .EQ. 5 .AND. IZ .EQ. 1) | IN = INIJ - 3 | SS8G448 |
| IF (INIJ .EQ. 6 .AND. IZ .EQ. 0) | IN = INIJ - 3 | SS8G449 |
| DO 811 NUVW=1,3 | | SS8G450 |
| DO 806 I=1,4 | | SS8G451 |
| DO 806 J=1,NTERMS | | SS8G452 |
| 806 CE(I,J)=C(1,I,NUVW,J) | | SS8G453 |
| CALL PPP (IN,NTERMS,IPOWER,ID,NUVW, 1) | | SS8G454 |
| DO 807 I=1,IPO2 | | SS8G455 |
| DO 807 J=1,NTERMS | | SS8G456 |
| IF (IN .EQ. 1) GO TO 807 | | SS8G457 |
| PZ(I,1,NUVW,J) = P(I,J) | | SS8G458 |
| 807 \$P(I,ID,1,NUVW,J) = P(I,J) | | SS8G459 |
| DO 808 I=1,4 | | SS8G460 |
| DO 808 J=1,NTERMS | | SS8G461 |
| 808 CE(I,J)=C(2,I,NUVW,J)*EP(J) | | SS8G462 |
| CALL PPP (IN,NTERMS,IPOWER,ID,NUVW, 2) | | SS8G463 |
| DO 809 I=1,IPO2 | | SS8G464 |
| DO 809 J=1,NTERMS | | SS8G465 |
| IF (IN .EQ. 1) GO TO 809 | | SS8G466 |
| PZ(I,2,NUVW,J) = P(I,J) | | SS8G467 |
| 809 \$P(I,ID,2,NUVW,J) = P(I,J) | | SS8G468 |
| DO 810 I=1,4 | | SS8G469 |
| DO 810 J=1,NTERMS | | SS8G470 |
| 810 CE(I,J)=C(3,I,NUVW,J)*EP(J)*EP(J) | | SS8G471 |
| CALL PPP (IN,NTERMS,IPOWER,ID,NUVW, 3) | | SS8G472 |
| DO 811 I=1,IPO2 | | SS8G473 |
| DO 811 J=1,NTERMS | | SS8G474 |
| IF (IN .EQ. 1) GO TO 811 | | SS8G475 |
| PZ(I,3,NUVW,J) = P(I,J) | | SS8G476 |
| 811 \$P(I,ID,3,NUVW,J) = P(I,J) | | SS8G477 |
| IF (IN .EQ. 1) GO TO 805 | | SS8G478 |
| CALL SPECIAL (IPOWER,NTERMS,INIJ,IDEFNE) | | SS8G479 |
| IN=IN-1 | | SS8G480 |
| 805 I=1 | | SS8G481 |
| DO 33 IUUVW=1,3 | | SS8G482 |
| DO 33 JUVW=1,3 | | SS8G483 |
| DO 33 K=1,6 | | SS8G484 |
| DO 33 N=1,NTERMS | | SS8G485 |
| DO 33 M=1,NTERMS | | SS8G486 |
| \$AL(I,MNIJ,K,IUUVW,N,JUVW,M)=AL(I,K,IUUVW,N,JUVW,M) | | SS8G487 |
| 33 CONTINUE | | SS8G488 |
| C THE MODE SHAPES AND ITS DERIVATIVES ARE EVALUATED AT 25 PCINTS. | | SS8G489 |
| DO 707 N=1,3 | | SS8G490 |
| DO 40 J=1 ,NTERMS | | SS8G491 |
| C(4,1,N,J)=C(3,3,N,J) | | SS8G492 |
| C(4,2,N,J)=C(3,4,N,J) | | SS8G493 |
| C(4,3,N,J)=C(3,1,N,J) | | SS8G494 |
| C(4,4,N,J)=-C(3,2,N,J) | | SS8G495 |
| DO 2750 I=1,4 | | SS8G496 |
| SAVE1 = C(I,1,N,J) | | SS8G497 |
| C(I,1,N,J)=C(I,1,N,J)+C(I,3,N,J) | | SS8G498 |
| 2750 C(I,3,N,J)=C(I,3,N,J) - SAVE1 | | SS8G499 |
| DO 40 L=1,25 | | SS8G500 |
| YU=L-1 | | SS8G501 |
| YU=YU/24. | | SS8G502 |
| AA=DEXP(EP(J)*YU) | | SS8G503 |

| | |
|--|---------|
| CN(1)=.5*(AA | SS8G504 |
| CN(3)=.5*(-1./AA) | SS8G505 |
| CN(2)=DCOS(EP(J)*YU) | SS8G506 |
| CN(4)=DSIN(EP(J)*YU) | SS8G507 |
| DO 40 I=1,4 | SS8G508 |
| EVAL(I,N,J,L)=0.DO | SS8G509 |
| DO 40 K=1,4 | SS8G510 |
| 40 EVAL(I,N,J,L)=EVAL(I,N,J,L)+CN(K)*C(I,K,N,J)*(EP(J)**(I-1)) | SS8G511 |
| IF (INIJ .EQ. 5 .AND. IZ .EQ. 1) GO TO 816 | SS8G512 |
| IF (INIJ .EQ. 6 .AND. IZ .EQ. 0) GO TO 816 | SS8G513 |
| GO TO 815 | SS8G514 |
| 816 DO 817 J=1,IN | SS8G515 |
| DO 817 L=1,25 | SS8G516 |
| DO 817 I=1,4 | SS8G517 |
| 817 EVAL(I,N,J,L)=EVQ(I,N,J,L) | SS8G518 |
| 815 CONTINUE | SS8G519 |
| 41 CONTINUE | SS8G520 |
| DO 707 K=1,NTERMS | SS8G521 |
| DO 707 L=1,25 | SS8G522 |
| DO 707 I=1,4 | SS8G523 |
| 707 \$EVAL(I,MNIJ,N,K,L)=EVAL(I,N,K,L) | SS8G524 |
| IF (MNIJ .EQ. 1) GO TO 59 | SS8G525 |
| IF (NSTRNG .EQ. 0) GO TO 90 | SS8G526 |
| DO 50 L=1,NSTRNG | SS8G527 |
| DO 50 J=1,NTERMS | SS8G528 |
| Y = \$STRNG(L) | SS8G529 |
| AA = DEXP(EP(J)*Y) | SS8G530 |
| CN(1) = .5*AA | SS8G531 |
| CN(3) = -.5/AA | SS8G532 |
| CN(2) = DCOS(EP(J)*Y) | SS8G533 |
| CN(4) = DSIN(EP(J)*Y) | SS8G534 |
| \$ESV(J,L) = 0. | SS8G535 |
| \$ESW(J,L) = 0. | SS8G536 |
| \$ESDW(J,L)= 0. | SS8G537 |
| DO 50 K=1,4 | SS8G538 |
| \$ESV(J,L) = \$ESV(J,L) + CN(K) * C(1,K,2,J) | SS8G539 |
| \$ESW(J,L) = \$ESW(J,L) + CN(K) * C(1,K,3,J) | SS8G540 |
| 50 \$ESDW(J,L)= \$ESDW(J,L)+ CN(K) * C(2,K,3,J)*EP(J) | SS8G541 |
| IF (INIJ .NE. 5) GO TO 52 | SS8G542 |
| IF (IZ .NE. 1) GO TO 52 | SS8G543 |
| DO 51 L=1,NSTRNG | SS8G544 |
| \$ESV(1,L) = S3 | SS8G545 |
| \$ESW(1,L) = S3 * \$STRNG(L) | SS8G546 |
| 51 \$ESDW(1,L) = S3 | SS8G547 |
| GO TO 90 | SS8G548 |
| 52 IF (INIJ .NE. 6) GO TO 90 | SS8G549 |
| IF (IZ .NE. 0) GO TO 90 | SS8G550 |
| DO 53 L=1,NSTRNG | SS8G551 |
| \$ESV(1,L) = 0. | SS8G552 |
| \$ESV(2,L) = -2.*S3 | SS8G553 |
| \$ESW(1,L) = 1. | SS8G554 |
| \$ESW(2,L) = S3 * (1. - 2. * \$STRNG(L)) | SS8G555 |
| \$ESDW(1,L)= 0. | SS8G556 |
| 53 \$ESDW(2,L)= -2.*S3 | SS8G557 |
| GO TO 90 | SS8G558 |
| 59 IF (NRING .EQ. 0) GO TO 90 | SS8G559 |

| | |
|---|---------|
| DO 60 L=1,NRING | SS8G560 |
| DO 60 J=1,NTERMS | SS8G561 |
| X = \$RINGS(L) | SS8G562 |
| AA = DEXP(EP(J)*X) | SS8G563 |
| CN(1) = .5*AA | SS8G564 |
| CN(3) = -.5/AA | SS8G565 |
| CN(2) = DCOS(EP(J)*X) | SS8G566 |
| CN(4) = DSIN(EP(J)*X) | SS8G567 |
| \$ERU(J,L) = 0. | SS8G568 |
| \$ERW(J,L) = 0. | SS8G569 |
| \$ERDW(J,L) = 0. | SS8G570 |
| DO 60 K=1,4 | SS8G571 |
| \$ERU(J,L) = \$ERU(J,L) + CN(K) * C(1,K,1,J) | SS8G572 |
| \$ERW(J,L) = \$ERW(J,L) + CN(K) * C(1,K,3,J) | SS8G573 |
| 60 \$ERDW(J,L) = \$ERDW(J,L) + CN(K) * C(2,K,3,J)*EP(J) | SS8G574 |
| IF (INIJ .NE. 5) GO TO 62 | SS8G575 |
| IF (IZ .NE. 1) GO TO 62 | SS8G576 |
| DO 61 L=1,NRING | SS8G577 |
| \$ERU(1,L) = S3 | SS8G578 |
| \$ERW(1,L) = S3*\$RINGS(L) | SS8G579 |
| 61 \$ERDW(1,L) = S3 | SS8G580 |
| GO TO 90 | SS8G581 |
| 62 IF (INIJ .NE. 6) GO TO 90 | SS8G582 |
| IF (IZ .NE. 0) GO TO 90 | SS8G583 |
| DO 63 L=1,NRING | SS8G584 |
| \$ERU(1,L) = 0. | SS8G585 |
| \$ERU(2,L) = -2.*S3 | SS8G586 |
| \$ERW(1,L) = 1. | SS8G587 |
| \$ERW(2,L) = S3*(1.-2.*\$RINGS(L)) | SS8G588 |
| \$ERDW(1,L) = 0. | SS8G589 |
| 63 \$ERDW(2,L) = -2.*S3 | SS8G590 |
| 90 CONTINUE | SS8G591 |
| RETURN | SS8G592 |
| END | SS8G593 |

CC = 00594

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SUBROUTINE ELASTC(RETURN,ALFA,BETA,N)                                SS8H000
C THIS SUBROUTINE COMPUTES THE FREQUENCIES (STORED IN EPI ) ) AND  SS8H001
C MODE SHAPES FOR A BEAM WITH ELASTIC MOMENT RESTRAINT AT BOTH ENDS. SS8H002
C THE MODE SHAPES ARE DEFINED BY MEANS OF FOUR CONSTANTS FOR EACH  SS8H003
C FREQUENCY, WHICH ARE RETURNED IN THE ARRAY NAMED RETURN( ). THE  SS8H004
C RESTRAINT IS SPECIFIED IN TERMS OF THE INPUT QUANTITIES ALPHA AND  SS8H005
C BETA. AT THE ZERO END, THE RESTRAINED BOUNDARY CONDITION IS THAT  SS8H006
C THE SLOPE = ALFA*CURVATURE. AT THE OTHER END, THE CONSTANT OF  SS8H007
C PROPORTIONALITY IS -BETA. THE ROOTS OF THE CHARACTERISTIC  SS8H008
C EQUATION ARE FOUND IN DOUBLE PRECISION USING AN INTERVAL HALFIN  SS8H009
C TECHNIQUE. THE INTERVAL IS HALVED 70 TIMES, SO THAT THE FINAL  SS8H010
C INTERVAL IS 1.6/(2**70)  SS8H011
C ** REVISED FOR CURVED PANELS - - 8/69  SS8H012
C IMPLICIT REAL*8(A-H,O-Z), INTEGER(I-N)  SS8H013
COMMON / BLOCK / AL(1,6,3,10,3,10), EVAL(4,3,10,25),  SS8H014
1 EVQ(4,3,2,25), PZ(11,3,3,10),  SS8H015
2 TH(10,4,4,3), ALVA(11,11,2), P(11,10),  SS8H016
3 CE(4,10), E(4,4), EP(10), CN(4), CM(4)  SS8H017
DIMENSION C(2,4), F(4), RETURN(4,10)  SS8H018
BETA = -BETA  SS8H019
AA=1.  SS8H020
C(1,3)=0.  SS8H021
C(1,4)=1.  SS8H022
C(2,3)=1.  SS8H023
C(2,4)=0.  SS8H024
DO 4 L=1,N  SS8H025
ELEFT=L  SS8H026
ELEFT=ELEFT*3.1415  SS8H027
ERIGHT=ELEFT+1.6  SS8H028
I=0  SS8H029
EPZ=ELEFT  SS8H030
GO TO 13  SS8H031
11 ELEFX=PTE  SS8H032
12 EPZ=(ELEFT+ ERIGHT)/2.  SS8H033
13 I=I+1  SS8H034
G1=ALFA/2./EPZ  SS8H035
G4=G1*BETA  SS8H036
C(1,1)=G1  SS8H037
C(1,2)= -G1  SS8H038
C(2,1)=G1  SS8H039
C(2,2)=-G1  SS8H040
EX=DEXP(EPZ)  SS8H041
EXX=1./EX  SS8H042
F(1)=.5*(EX+EXX)  SS8H043
F(2)=DCOS(EPZ)  SS8H044
F(3)=.5*(EX-EXX)  SS8H045
F(4)=DSIN(EPZ)  SS8H046
PTE= -G4*2.*(1. -F(1)*F(2)) +(ALFA -BETA) *( F(1)*F(4) - F(3)*  SS8H047
1F(2)) + 2.*EPZ*F(3)*F(4)  SS8H048
IF(I.LT.2) GO TO 11  SS8H049
IF(PTE*ELEFX)16,17,18  SS8H050
16 ERIGHT = EPZ  SS8H051
GO TO 19  SS8H052
18 ELEFT= EPZ  SS8H053
ELEFX = PTE  SS8H054
19 IF(I.LT.30)GO TO 12  SS8H055

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17 CONTINUE
8 PTE = 0.
  PJA = 0.
  DO 9 J=1,4
    PTE= PTE+ C(2,J)*F(J)
9 PJA= PJA+ C(1,J)*F(J)
  CC=-PJA/PTE
  BB=-(AA+CC)*G1
  DD=-BB
  RETURN(1,L) = DD
  RETURN(2,L) = BB
  RETURN(3,L) = CC
  RETURN(4,L) = AA
  EP(L) = EPZ
4 CONTINUE
  RETURN
  END

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SS8H056
SS8H057
SS8H058
SS8H059
SS8H060
SS8H061
SS8H062
SS8H063
SS8H064
SS8H065
SS8H066
SS8H067
SS8H068
SS8H069
SS8H070
SS8H071
SS8H072

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CC = 00073

| | | |
|------|--|---------|
| | SUBROUTINE PPP (IN, NTERMS, IPOW, ID, NUW, IR) | SS81000 |
| C | THIS SUBROUTINE COMPUTES THE 'P' INTEGRALS--THE INTEGRALS OF A | SS81001 |
| C | SINGLE MODE SHAPE OR ITS DERIVATIVE. THE INPUT IS IN (THE NUMBER | SS81002 |
| C | OF SPECIAL CASES PLUS ONE), THE ARRAY CE() WHICH CONTAINS THE | SS81003 |
| C | FOUR COEFFICIENTS OF THE MODE SHAPE (OR ITS DERIVATIVE) WHICH IS | SS81004 |
| C | TO BE INTEGRATED. THE OUTPUT IS THE ARRAY P() CONTAINING THE | SS81005 |
| C | INTEGRALS. THE ROUTINE ALSO NEEDS THE VALUES OF EP(), ENTERED | SS81006 |
| C | THROUGH COMMON. THE ROUTINE IS IN DOUBLE PRECISION. | SS81007 |
| C ** | REVISED FOR CURVED PANELS -- 8/69 | SS81008 |
| | IMPLICIT REAL*8(A-H,O-Z), INTEGER (I-N) | SS81009 |
| | COMMON / BLOCK / AL(1,6,3,10,3,10), EVAL(4,3,10,25), | SS81010 |
| 1 | EVQ(4,3,2,25), PZ(11,3,3,10), | SS81011 |
| 2 | TH(10,4,4,3), ALVA(11,11,2), P(11,10), | SS81012 |
| 3 | CE(4,10), E(4,4), EP(10), CN(4), CM(4) | SS81013 |
| | DIMENSION G(4), C(12,4,10), F(4) | SS81014 |
| | IPOW2=IPOW+1 | SS81015 |
| | PETE=3. | SS81016 |
| | AQB= -1. | SS81017 |
| | S3=DSQRT(PETE) | SS81018 |
| | IF(IN.EQ.3) GO TO 60 | SS81019 |
| | IF(IN.EQ.2) GO TO 50 | SS81020 |
| | IF(IN.EQ.1) GO TO 61 | SS81021 |
| C | SPECIAL CASES ARE COMPUTED FIRST. | SS81022 |
| 50 | IF(NUW.EQ.3) GO TO 210 | SS81023 |
| | IF(ID.NE.1) GO TO 230 | SS81024 |
| | IF(NUW.NE.1) GO TO 210 | SS81025 |
| 190 | DO 200 I=1, IPOW2 | SS81026 |
| | T=I | SS81027 |
| | P(I,1) = S3/T | SS81028 |
| | IF (IR .NE. 1) P(I,1) = 0.00 | SS81029 |
| 200 | CONTINUE | SS81030 |
| | GO TO 61 | SS81031 |
| 210 | DO 220 I=1, IPOW2 | SS81032 |
| | T=I+1 | SS81033 |
| | IF (IR .EQ. 1) P(I,1) = S3/T | SS81034 |
| | IF (IR .EQ. 2) P(I,1) = S3/(T-1.) | SS81035 |
| | IF (IR .EQ. 3) P(I,1) = 0.00 | SS81036 |
| 220 | CONTINUE | SS81037 |
| | GO TO 61 | SS81038 |
| 230 | IF(NUW.EQ.1) GO TO 210 | SS81039 |
| | GO TO 190 | SS81040 |
| 60 | IF (NUW.EQ.3) GO TO 310 | SS81041 |
| | IF (ID.NE.1) GO TO 330 | SS81042 |
| | IF (NUW.NE.1) GO TO 310 | SS81043 |
| 290 | DO 300 I=1, IPOW2 | SS81044 |
| | T=I | SS81045 |
| | P(I,1) = 0.00 | SS81046 |
| | P(I,2) = 0.00 | SS81047 |
| | IF (IR .EQ. 1) P(I,2) = -2.00*S3/T | SS81048 |
| 300 | CONTINUE | SS81049 |
| | GO TO 61 | SS81050 |
| 310 | DO 320 I=1, IPOW2 | SS81051 |
| | T=I | SS81052 |
| | TT= 1./T -2./(T+1.) | SS81053 |
| | P(I,1) = 0.00 | SS81054 |
| | P(I,2) = 0.00 | SS81055 |

| | |
|--|---------|
| IF (IR .EQ. 1) P(I,1) = 1.D0/T | SS8I056 |
| IF (IR .EQ. 1) P(I,2) = S3*TT | SS8I057 |
| IF (IR .EQ. 2) P(I,2) = -2.D0*S3/T | SS8I058 |
| 320 CONTINUE | SS8I059 |
| GO TO 61 | SS8I060 |
| 330 IF (NUVW.EQ.1) GO TO 310 | SS8I061 |
| GO TO 290 | SS8I062 |
| 61 INN= IN | SS8I063 |
| G(1)=1. | SS8I064 |
| G(2)=1. | SS8I065 |
| G(3)=0. | SS8I066 |
| G(4)=0. | SS8I067 |
| DO 1 L=INN, NTERMS | SS8I068 |
| EX=DEXP(EP(L)) | SS8I069 |
| SH=.5*(EX-1./EX) | SS8I070 |
| SN=DSIN(EP(L)) | SS8I071 |
| CS=DCOS(EP(L)) | SS8I072 |
| CH=.5*(EX+1./EX) | SS8I073 |
| DO 2 J=1, IPOW2, 2 | SS8I074 |
| C(J,1,L)=CE(3,L)/(EP(L)**J) | SS8I075 |
| C(J,3,L)=CE(1,L)/(EP(L)**J) | SS8I076 |
| C(J+1,1,L)=CE(1,L)/(EP(L)**(J+1)) | SS8I077 |
| 2 C(J+1,3,L)=CE(3,L)/(EP(L)**(J+1)) | SS8I078 |
| IJK=0 | SS8I079 |
| DO 10 J=1, IPOW2, 2 | SS8I080 |
| IJK= IJK+ 1 | SS8I081 |
| C(J,2,L)= (AQB**IJK)*CE(4,L)/(EP(L)**J) | SS8I082 |
| C(J+1,2,L)= (AQB**IJK)*CE(2,L)/(EP(L)**(J+1)) | SS8I083 |
| C(J,4,L)=-(AQB** IJK)*CE(2,L)/(EP(L)**J) | SS8I084 |
| 10 C(J+1,4,L)= (AQB** (IJK))*CE(4,L)/(EP(L)**(J+1)) | SS8I085 |
| F(1)=CH | SS8I086 |
| F(2)=CS | SS8I087 |
| F(3)=SH | SS8I088 |
| F(4)=SN | SS8I089 |
| DO 4 I=1, IPOW2 | SS8I090 |
| 4 P(I,L)=0. | SS8I091 |
| DO 1 I=1, 4 | SS8I092 |
| DO 1 JJ=1, IPOW2 | SS8I093 |
| DO 100 KK =1, JJ | SS8I094 |
| 100 P(JJ,L) = P(JJ,L) + C(KK,I,L)*F(I)*ALVA(JJ, KK, 1) | SS8I095 |
| 1 P(JJ,L) = P(JJ,L) - C(JJ,I,L)*G(I)*ALVA(JJ, JJ, 2) | SS8I096 |
| RETURN | SS8I097 |
| END | SS8I098 |

CC = 00099

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SUBROUTINE SPECIAL (IPOWER,NTERMS,MNIJ,IDEFNE)                                SS8J000
C THIS SUBROUTINE COMPUTES THE 'SPECIAL' CASES INTEGRALS FOR FREE- SS8J001
C FREE AND SIMPLE FREE BEAM SHAPES. THE INPUT NECESSARY IS THE SS8J002
C 'P' INTEGRALS FROM SUBROUTINE PPP FOR THE CONDITION THE SUBROUTINE SS8J003
C IS BEING USED FOR (MNIJ=5 FOR SIMPLE-FREE, 6 FOR FREE-FREE). THE SS8J004
C SUBROUTINE RETURNS THE INTEGRALS IN THE ARRAY ALL. THE MODE SHAPE SS8J005
C EVALUATIONS, AND DERIVATIVE EVALUATIONS, FOR THE SPECIAL CASES ARE SS8J006
C MADE AND RETURNED IN EVQ. THE ROUTINE IS IN DOUBLE PRECISION. SS8J007
C ** REWRITTEN FOR CURVED PANELS - - 8/69 SS8J008
C IMPLICIT REAL*8(A-H,O-Z), INTEGER (I-N) SS8J009
COMMON / BLOCK / AL( 6,3,10,3,10), EXAL(4,3,10,25), SS8J010
1 EVAL(4,3,2,25), P(11,3,3,10), SS8J011
2 TH(10,4,4,3), ALVA(11,11,2), PDUM(11,10), SS8J012
3 CE(4,10), E(4,4), EP(10), CN(4), CM(4) SS8J013
COMMON / ARRAYS / $P(11,2,3,3,10), $AL(1,2,6,3,10,3,10), SS8J014
1 $W(10,2,3,10,10) SS8J015
ID=IDEFNE SS8J016
IF(ID.EQ.1) JD=2 SS8J017
IF(ID.EQ.2) JD=1 SS8J018
S3 = DSQRT ( 3.DO ) SS8J019
C THE INTEGRALS ARE EVALUATED FROM HERE TO STATEMENT 1 . SS8J020
I = 1 SS8J021
T=I SS8J022
C SIMPLE - FREE BOUNDARY CONDITION SS8J023
IF (MNIJ.NE.5) GO TO 200 SS8J024
DO 90 K=1,6 SS8J025
DO 90 IUVW=1,3 SS8J026
DO 90 JUVW=1,3 SS8J027
DO 90 M=1,NTERMS SS8J028
AL(K,IUVW,1,JUVW,M) = 0.DO SS8J029
90 AL(K,IUVW,M,JUVW,1) = 0.DO SS8J030
AL(1,ID,1,ID,1)= 3.DO SS8J031
AL(1,ID,1,ID,1)= 1.5DO SS8J032
AL(1,ID,1,3 ,1)= 1.5DO SS8J033
AL(1,JD,1,ID,1)= 1.5DO SS8J034
AL(4,JD,1,ID,1)= 3.DO SS8J035
AL(1,JD,1,JD,1)= 1.DO SS8J036
AL(2,JD,1,JD,1)= 3.DO SS8J037
AL(4,JD,1,JD,1)= 1.5DO SS8J038
AL(1,JD,1,3 ,1)= 1.DO SS8J039
AL(2,JD,1,3 ,1)= 3.DO SS8J040
AL(4,JD,1,3 ,1)= 1.5DO SS8J041
AL(1,3 ,1,ID,1)= 1.5DO SS8J042
AL(4,3 ,1,ID,1)= 3.DO SS8J043
AL(1,3 ,1,JD,1)= 1.DO SS8J044
AL(2,3 ,1,JD,1)= 3.DO SS8J045
AL(4,3 ,1,JD,1)= 1.5DO SS8J046
AL(1,3 ,1,3 ,1)= 1.DO SS8J047
AL(2,3 ,1,3 ,1)= 3.DO SS8J048
AL(4,3 ,1,3 ,1)= 1.5DO SS8J049
IF ( NTERMS.EQ.1 ) GO TO 101 SS8J050
DO 100 M=2,NTERMS SS8J051
AL(1,ID,1,ID,M)= S3*P(1,1,ID,M) SS8J052
AL(1,ID,1,JD,M)= S3*P(1,1,JD,M) SS8J053
AL(1,ID,1,3 ,M)= S3*P(1,1,3 ,M) SS8J054
AL(1,ID,M,ID,1)= S3*P(1,1,ID,M) SS8J055

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| AL(4, ID, M, ID, 1)= S3*P(1, 2, ID, M) | SS8J056 |
| AL(5, ID, M, ID, 1)= S3*P(1, 3, ID, M) | SS8J057 |
| AL(1, ID, M, JD, 1)= S3*P(2, 1, ID, M) | SS8J058 |
| AL(2, ID, M, JD, 1)= S3*P(1, 2, ID, M) | SS8J059 |
| AL(4, ID, M, JD, 1)= S3*P(2, 2, ID, M) | SS8J060 |
| AL(5, ID, M, JD, 1)= S3*P(2, 3, ID, M) | SS8J061 |
| AL(6, ID, M, JD, 1)= S3*P(1, 3, ID, M) | SS8J062 |
| AL(1, ID, M, 3, 1)= S3*P(2, 1, ID, M) | SS8J063 |
| AL(2, ID, M, 3, 1)= S3*P(1, 2, ID, M) | SS8J064 |
| AL(4, ID, M, 3, 1)= S3*P(2, 2, ID, M) | SS8J065 |
| AL(5, ID, M, 3, 1)= S3*P(2, 3, ID, M) | SS8J066 |
| AL(6, ID, M, 3, 1)= S3*P(1, 3, ID, M) | SS8J067 |
| AL(1, JD, 1, ID, M)= S3*P(2, 1, ID, M) | SS8J068 |
| AL(2, JD, 1, ID, M)= S3*P(1, 2, ID, M) | SS8J069 |
| AL(4, JD, 1, ID, M)= S3*P(1, 1, ID, M) | SS8J070 |
| AL(1, JD, 1, JD, M)= S3*P(2, 1, JD, M) | SS8J071 |
| AL(2, JD, 1, JD, M)= S3*P(1, 2, JD, M) | SS8J072 |
| AL(4, JD, 1, JD, M)= S3*P(1, 1, JD, M) | SS8J073 |
| AL(1, JD, 1, 3, M)= S3*P(2, 1, 3, M) | SS8J074 |
| AL(2, JD, 1, 3, M)= S3*P(1, 2, 3, M) | SS8J075 |
| AL(4, JD, 1, 3, M)= S3*P(1, 1, 3, M) | SS8J076 |
| AL(1, JD, M, ID, 1)= S3*P(1, 1, JD, M) | SS8J077 |
| AL(4, JD, M, ID, 1)= S3*P(1, 2, JD, M) | SS8J078 |
| AL(5, JD, M, ID, 1)= S3*P(1, 3, JD, M) | SS8J079 |
| AL(1, JD, M, JD, 1)= S3*P(2, 1, JD, M) | SS8J080 |
| AL(2, JD, M, JD, 1)= S3*P(1, 2, JD, M) | SS8J081 |
| AL(4, JD, M, JD, 1)= S3*P(2, 2, JD, M) | SS8J082 |
| AL(5, JD, M, JD, 1)= S3*P(2, 3, JD, M) | SS8J083 |
| AL(6, JD, M, JD, 1)= S3*P(1, 3, JD, M) | SS8J084 |
| AL(1, JD, M, 3, 1)= S3*P(2, 1, JD, M) | SS8J085 |
| AL(2, JD, M, 3, 1)= S3*P(1, 2, JD, M) | SS8J086 |
| AL(4, JD, M, 3, 1)= S3*P(2, 2, JD, M) | SS8J087 |
| AL(5, JD, M, 3, 1)= S3*P(2, 3, JD, M) | SS8J088 |
| AL(6, JD, M, 3, 1)= S3*P(1, 3, JD, M) | SS8J089 |
| AL(1, 3, 1, ID, M)= S3*P(2, 1, ID, M) | SS8J090 |
| AL(2, 3, 1, ID, M)= S3*P(1, 2, ID, M) | SS8J091 |
| AL(4, 3, 1, ID, M)= S3*P(1, 1, ID, M) | SS8J092 |
| AL(1, 3, 1, JD, M)= S3*P(2, 1, JD, M) | SS8J093 |
| AL(2, 3, 1, JD, M)= S3*P(1, 2, JD, M) | SS8J094 |
| AL(4, 3, 1, JD, M)= S3*P(1, 1, JD, M) | SS8J095 |
| AL(1, 3, 1, 3, M)= S3*P(2, 1, 3, M) | SS8J096 |
| AL(2, 3, 1, 3, M)= S3*P(1, 2, 3, M) | SS8J097 |
| AL(4, 3, 1, 3, M)= S3*P(1, 1, 3, M) | SS8J098 |
| AL(1, 3, M, ID, 1)= S3*P(1, 1, 3, M) | SS8J099 |
| AL(4, 3, M, ID, 1)= S3*P(1, 2, 3, M) | SS8J100 |
| AL(5, 3, M, ID, 1)= S3*P(1, 3, 3, M) | SS8J101 |
| AL(1, 3, M, JD, 1)= S3*P(2, 1, 3, M) | SS8J102 |
| AL(2, 3, M, JD, 1)= S3*P(1, 2, 3, M) | SS8J103 |
| AL(4, 3, M, JD, 1)= S3*P(2, 2, 3, M) | SS8J104 |
| AL(5, 3, M, JD, 1)= S3*P(2, 3, 3, M) | SS8J105 |
| AL(6, 3, M, JD, 1)= S3*P(1, 3, 3, M) | SS8J106 |
| AL(1, 3, M, 3, 1)= S3*P(2, 1, 3, M) | SS8J107 |
| AL(2, 3, M, 3, 1)= S3*P(1, 2, 3, M) | SS8J108 |
| AL(4, 3, M, 3, 1)= S3*P(2, 2, 3, M) | SS8J109 |
| AL(5, 3, M, 3, 1)= S3*P(2, 3, 3, M) | SS8J110 |
| AL(6, 3, M, 3, 1)= S3*P(1, 3, 3, M) | SS8J111 |

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|--|---------|
| 100 CONTINUE | SS8J112 |
| 101 CONTINUE | SS8J113 |
| DO 122 I=1, IPOWER | SS8J114 |
| T = I | SS8J115 |
| \$W(I, ID, 1, 1, 1) = 3./(2.+T) | SS8J116 |
| \$W(I, ID, 2, 1, 1) = 3./T | SS8J117 |
| \$W(I, ID, 3, 1, 1) = 3./(1.+T) | SS8J118 |
| IF (NTERMS.EQ.1) GO TO 125 | SS8J119 |
| DO 122 M=2, NTERMS | SS8J120 |
| Z = S3*P(I+1, 1, 3, M) | SS8J121 |
| \$W(I, ID, 1, 1, M) = Z | SS8J122 |
| \$W(I, ID, 1, M, 1) = Z | SS8J123 |
| Z = S3*P(I, 2, 3, M) | SS8J124 |
| \$W(I, ID, 2, 1, M) = Z | SS8J125 |
| \$W(I, ID, 2, M, 1) = Z | SS8J126 |
| \$W(I, ID, 3, 1, M) = S3*P(I, 1, 3, M) | SS8J127 |
| \$W(I, ID, 3, M, 1) = S3*P(I+1, 2, 3, M) | SS8J128 |
| 122 CONTINUE | SS8J129 |
| GO TO 125 | SS8J130 |
| C FREE - FREE BOUNDARY CONDITION | SS8J131 |
| 200 CONTINUE | SS8J132 |
| DO 205 K=1, 6 | SS8J133 |
| DO 205 KUVW=1, 2 | SS8J134 |
| DO 205 IUVW=1, 3 | SS8J135 |
| DO 205 JUVW=1, 3 | SS8J136 |
| DO 205 M=1, NTERMS | SS8J137 |
| AL(K, IUVW, KUVW, JUVW, M)=0.DO | SS8J138 |
| AL(K, IUVW, M, JUVW, KUVW)=0.DO | SS8J139 |
| 205 CONTINUE | SS8J140 |
| S = S3 | SS8J141 |
| T = 2.DO*S3 | SS8J142 |
| AL(1, ID, 2, ID, 2)= 12.DO | SS8J143 |
| AL(1, ID, 2, JD, 1)= -T | SS8J144 |
| AL(1, ID, 2, 3, 1)= -T | SS8J145 |
| AL(1, JD, 1, ID, 2)= -T | SS8J146 |
| AL(1, JD, 1, JD, 1)= 1.DO | SS8J147 |
| AL(1, JD, 1, 3, 1)= 1.DO | SS8J148 |
| AL(4, JD, 2, ID, 2)= 12.DO | SS8J149 |
| AL(4, JD, 2, JD, 1)= -T | SS8J150 |
| AL(1, JD, 2, JD, 2)= 1.DO | SS8J151 |
| AL(2, JD, 2, JD, 2)= 12.DO | SS8J152 |
| AL(4, JD, 2, 3, 1)= -T | SS8J153 |
| AL(1, JD, 2, 3, 2)= 1.DO | SS8J154 |
| AL(2, JD, 2, 3, 2)= 12.DO | SS8J155 |
| AL(1, 3, 1, ID, 2)= -T | SS8J156 |
| AL(1, 3, 1, JD, 1)= 1.DO | SS8J157 |
| AL(1, 3, 1, 3, 1)= 1.DO | SS8J158 |
| AL(4, 3, 2, ID, 2)= 12.DO | SS8J159 |
| AL(4, 3, 2, JD, 1)= -T | SS8J160 |
| AL(1, 3, 2, JD, 2)= 1.DO | SS8J161 |
| AL(2, 3, 2, JD, 2)= 12.DO | SS8J162 |
| AL(4, 3, 2, 3, 1)= -T | SS8J163 |
| AL(1, 3, 2, 3, 2)= 1.DO | SS8J164 |
| AL(2, 3, 2, 3, 2)= 12.DO | SS8J165 |
| DO 210 M=3, NTERMS | SS8J166 |
| AL(1, ID, 2, ID, M)= -T*P(1, 1, ID, M) | SS8J167 |

| | | |
|-----------------------|------------------------------------|---------|
| AL(1, ID, 2, JD, M) = | -T*P(1, 1, JD, M) | SS8J168 |
| AL(1, ID, 2, 3 , M) = | -T*P(1, 1, 3 , M) | SS8J169 |
| AL(1, ID, M, ID, 2) = | -T*P(1, 1, ID, M) | SS8J170 |
| AL(4, ID, M, ID, 2) = | -T*P(1, 2, ID, M) | SS8J171 |
| AL(5, ID, M, ID, 2) = | -T*P(1, 3, ID, M) | SS8J172 |
| AL(1, ID, M, JD, 1) = | P(1, 1, ID, M) | SS8J173 |
| AL(4, ID, M, JD, 1) = | P(1, 2, ID, M) | SS8J174 |
| AL(5, ID, M, JD, 1) = | P(1, 3, ID, M) | SS8J175 |
| AL(1, ID, M, JD, 2) = | S*P(1, 1, ID, M) -T*P(2, 1, ID, M) | SS8J176 |
| AL(2, ID, M, JD, 2) = | -T*P(1, 2, ID, M) | SS8J177 |
| AL(4, ID, M, JD, 2) = | S*P(1, 2, ID, M) -T*P(2, 2, ID, M) | SS8J178 |
| AL(5, ID, M, JD, 2) = | S*P(1, 3, ID, M) -T*P(2, 3, ID, M) | SS8J179 |
| AL(6, ID, M, JD, 2) = | -T*P(1, 3, ID, M) | SS8J180 |
| AL(1, ID, M, 3 , 1) = | P(1, 1, ID, M) | SS8J181 |
| AL(4, ID, M, 3 , 1) = | P(1, 2, ID, M) | SS8J182 |
| AL(5, ID, M, 3 , 1) = | P(1, 3, ID, M) | SS8J183 |
| AL(1, ID, M, 3 , 2) = | S*P(1, 1, ID, M) -T*P(2, 1, ID, M) | SS8J184 |
| AL(2, ID, M, 3 , 2) = | -T*P(1, 2, ID, M) | SS8J185 |
| AL(4, ID, M, 3 , 2) = | S*P(1, 2, ID, M) -T*P(2, 2, ID, M) | SS8J186 |
| AL(5, ID, M, 3 , 2) = | S*P(1, 3, ID, M) -T*P(2, 3, ID, M) | SS8J187 |
| AL(6, ID, M, 3 , 2) = | -T*P(1, 3, ID, M) | SS8J188 |
| AL(1, JD, 1, ID, M) = | P(1, 1, ID, M) | SS8J189 |
| AL(1, JD, 1, JD, M) = | P(1, 1, JD, M) | SS8J190 |
| AL(1, JD, 1, 3 , M) = | P(1, 1, 3 , M) | SS8J191 |
| AL(1, JD, 2, ID, M) = | S*P(1, 1, ID, M) -T*P(2, 1, ID, M) | SS8J192 |
| AL(2, JD, 2, ID, M) = | -T*P(1, 2, ID, M) | SS8J193 |
| AL(4, JD, 2, ID, M) = | -T*P(1, 1, ID, M) | SS8J194 |
| AL(1, JD, 2, JD, M) = | S*P(1, 1, JD, M) -T*P(2, 1, JD, M) | SS8J195 |
| AL(2, JD, 2, JD, M) = | -T*P(1, 2, JD, M) | SS8J196 |
| AL(4, JD, 2, JD, M) = | -T*P(1, 1, JD, M) | SS8J197 |
| AL(1, JD, 2, 3 , M) = | S*P(1, 1, 3 , M) -T*P(2, 1, 3 , M) | SS8J198 |
| AL(2, JD, 2, 3 , M) = | -T*P(1, 2, 3 , M) | SS8J199 |
| AL(4, JD, 2, 3 , M) = | -T*P(1, 1, 3 , M) | SS8J200 |
| AL(1, JD, M, ID, 2) = | -T*P(1, 1, JD, M) | SS8J201 |
| AL(4, JD, M, ID, 2) = | -T*P(1, 2, JD, M) | SS8J202 |
| AL(5, JD, M, ID, 2) = | -T*P(1, 3, JD, M) | SS8J203 |
| AL(1, JD, M, JD, 1) = | P(1, 1, JD, M) | SS8J204 |
| AL(4, JD, M, JD, 1) = | P(1, 2, JD, M) | SS8J205 |
| AL(5, JD, M, JD, 1) = | P(1, 3, JD, M) | SS8J206 |
| AL(1, JD, M, JD, 2) = | S*P(1, 1, JD, M) -T*P(2, 1, JD, M) | SS8J207 |
| AL(2, JD, M, JD, 2) = | -T*P(1, 2, JD, M) | SS8J208 |
| AL(4, JD, M, JD, 2) = | S*P(1, 2, JD, M) -T*P(2, 2, JD, M) | SS8J209 |
| AL(5, JD, M, JD, 2) = | S*P(1, 3, JD, M) -T*P(2, 3, JD, M) | SS8J210 |
| AL(6, JD, M, JD, 2) = | -T*P(1, 3, JD, M) | SS8J211 |
| AL(1, JD, M, 3 , 1) = | P(1, 1, JD, M) | SS8J212 |
| AL(4, JD, M, 3 , 1) = | P(1, 2, JD, M) | SS8J213 |
| AL(5, JD, M, 3 , 1) = | P(1, 3, JD, M) | SS8J214 |
| AL(1, JD, M, 3 , 2) = | S*P(1, 1, JD, M) -T*P(2, 1, JD, M) | SS8J215 |
| AL(2, JD, M, 3 , 2) = | -T*P(1, 2, JD, M) | SS8J216 |
| AL(4, JD, M, 3 , 2) = | S*P(1, 2, JD, M) -T*P(2, 2, JD, M) | SS8J217 |
| AL(5, JD, M, 3 , 2) = | S*P(1, 3, JD, M) -T*P(2, 3, JD, M) | SS8J218 |
| AL(6, JD, M, 3 , 2) = | -T*P(1, 3, JD, M) | SS8J219 |
| AL(1, 3 , 1, ID, M) = | P(1, 1, ID, M) | SS8J220 |
| AL(1, 3 , 1, JD, M) = | P(1, 1, JD, M) | SS8J221 |
| AL(1, 3 , 1, 3 , M) = | P(1, 1, 3 , M) | SS8J222 |
| AL(1, 3 , 2, ID, M) = | S*P(1, 1, ID, M) -T*P(2, 1, ID, M) | SS8J223 |

| | |
|--|---------|
| AL(2,3,2,ID,M) = -T*P(1,2,ID,M) | SS8J224 |
| AL(4,3,2,ID,M) = -T*P(1,1,ID,M) | SS8J225 |
| AL(1,3,2,JD,M) = S*P(1,1,JD,M) -T*P(2,1,JD,M) | SS8J226 |
| AL(2,3,2,JD,M) = -T*P(1,2,JD,M) | SS8J227 |
| AL(4,3,2,JD,M) = -T*P(1,1,JD,M) | SS8J228 |
| AL(1,3,2,3,M) = S*P(1,1,3,M) -T*P(2,1,3,M) | SS8J229 |
| AL(2,3,2,3,M) = -T*P(1,2,3,M) | SS8J230 |
| AL(4,3,2,3,M) = -T*P(1,1,3,M) | SS8J231 |
| AL(1,3,M,ID,2) = -T*P(1,1,3,M) | SS8J232 |
| AL(4,3,M,ID,2) = -T*P(1,2,3,M) | SS8J233 |
| AL(5,3,M,ID,2) = -T*P(1,3,3,M) | SS8J234 |
| AL(1,3,M,JD,1) = P(1,1,3,M) | SS8J235 |
| AL(4,3,M,JD,1) = P(1,2,3,M) | SS8J236 |
| AL(5,3,M,JD,1) = P(1,3,3,M) | SS8J237 |
| AL(1,3,M,JD,2) = S*P(1,1,3,M) -T*P(2,1,3,M) | SS8J238 |
| AL(2,3,M,JD,2) = -T*P(1,2,3,M) | SS8J239 |
| AL(4,3,M,JD,2) = S*P(1,2,3,M) -T*P(2,2,3,M) | SS8J240 |
| AL(5,3,M,JD,2) = S*P(1,3,3,M) -T*P(2,3,3,M) | SS8J241 |
| AL(6,3,M,JD,2) = -T*P(1,3,3,M) | SS8J242 |
| AL(1,3,M,3,1) = P(1,1,3,M) | SS8J243 |
| AL(4,3,M,3,1) = P(1,2,3,M) | SS8J244 |
| AL(5,3,M,3,1) = P(1,3,3,M) | SS8J245 |
| AL(1,3,M,3,2) = S*P(1,1,3,M) -T*P(2,1,3,M) | SS8J246 |
| AL(2,3,M,3,2) = -T*P(1,2,3,M) | SS8J247 |
| AL(4,3,M,3,2) = S*P(1,2,3,M) -T*P(2,2,3,M) | SS8J248 |
| AL(5,3,M,3,2) = S*P(1,3,3,M) -T*P(2,3,3,M) | SS8J249 |
| AL(6,3,M,3,2) = -T*P(1,3,3,M) | SS8J250 |
| 210 CONTINUE | SS8J251 |
| DO 236 I=1,IPOWER | SS8J252 |
| T = I | SS8J253 |
| \$W(I,ID,1,1,1) = 1./T | SS8J254 |
| \$W(I,ID,2,1,1) = 0. | SS8J255 |
| \$W(I,ID,3,1,1) = 0. | SS8J256 |
| \$W(I,ID,1,1,2) = S3*(1./T-2./((T+1.)) | SS8J257 |
| \$W(I,ID,2,1,2) = 0. | SS8J258 |
| \$W(I,ID,3,1,2) = 0. | SS8J259 |
| \$W(I,ID,1,2,1) = S3*(1./T-2./((T+1.)) | SS8J260 |
| \$W(I,ID,2,2,1) = 0. | SS8J261 |
| \$W(I,ID,3,2,1) = -2.*S3/T | SS8J262 |
| \$W(I,ID,1,2,2) = 3.*(1./T-4./((T+1.))+4./((T+2.)) | SS8J263 |
| \$W(I,ID,2,2,2) = 12./T | SS8J264 |
| \$W(I,ID,3,2,2) = -6.*(1./T-2./((T+1.)) | SS8J265 |
| IF (M.LE.2) GO TO 236 | SS8J266 |
| DO 235 M=3,NTERMS | SS8J267 |
| \$W(I,ID,1,1,M) = P(I,1,3,M) | SS8J268 |
| \$W(I,ID,2,1,M) = 0. | SS8J269 |
| \$W(I,ID,3,1,M) = 0. | SS8J270 |
| \$W(I,ID,1,M,1) = P(I,1,3,M) | SS8J271 |
| \$W(I,ID,2,M,1) = 0. | SS8J272 |
| \$W(I,ID,3,M,1) = P(I,2,3,M) | SS8J273 |
| \$W(I,ID,1,2,M) = S3*(P(I,1,3,M)-2.*P(I+1,1,3,M)) | SS8J274 |
| \$W(I,ID,2,2,M) = -2.*S3*P(I,2,3,M) | SS8J275 |
| \$W(I,ID,3,2,M) = -2.*S3*P(I,1,3,M) | SS8J276 |
| \$W(I,ID,1,M,2) = S3*(P(I,1,3,M)-2.*P(I+1,1,3,M)) | SS8J277 |
| \$W(I,ID,2,M,2) = -2.*S3*P(I,2,3,M) | SS8J278 |
| 235 \$W(I,ID,3,M,2) = S3*(P(I,2,3,M)-2.*P(I+1,2,3,M)) | SS8J279 |

| | | |
|-----|---------------------------------------|---------|
| 236 | CONTINUE | SS8J280 |
| 125 | CONTINUE | SS8J281 |
| C | CALCULATE MODE SHAPES AND DERIVATIVES | SS8J282 |
| | DO 400 I=1,25 | SS8J283 |
| | W=I-1 | SS8J284 |
| | W=W/24. | SS8J285 |
| | IF(MNIJ.NE.5) GO TO 300 | SS8J286 |
| | EVAL(1,3,1,I)= S3*W | SS8J287 |
| | EVAL(2,3,1,I)= S3 | SS8J288 |
| | EVAL(1,JD,1,I)= S3*W | SS8J289 |
| | EVAL(2,JD,1,I)= S3 | SS8J290 |
| | EVAL(1,ID,1,I)= S3 | SS8J291 |
| | EVAL(2,ID,1,I)= 0.00 | SS8J292 |
| | GO TO 400 | SS8J293 |
| 300 | EVAL(1,3,1,I)= 1.00 | SS8J294 |
| | EVAL(2,3,1,I)= 0.00 | SS8J295 |
| | EVAL(1,3,2,I)= S3*(1.00-2.00*W) | SS8J296 |
| | EVAL(2,3,2,I)= -2.00*S3 | SS8J297 |
| | EVAL(1,JD,1,I)= 1.00 | SS8J298 |
| | EVAL(2,JD,1,I)= 0.00 | SS8J299 |
| | EVAL(1,JD,2,I)= S3*(1.00-2.00*W) | SS8J300 |
| | EVAL(2,JD,2,I)= -2.00*S3 | SS8J301 |
| | EVAL(1,ID,1,I)= 0. | SS8J302 |
| | EVAL(2,ID,1,I)= 0.00 | SS8J303 |
| | EVAL(1,ID,2,I)= -2.00*S3 | SS8J304 |
| | EVAL(2,ID,2,I)= 0.00 | SS8J305 |
| 400 | CONTINUE | SS8J306 |
| | INNN=MNIJ-4 | SS8J307 |
| | DO 500 L=1,25 | SS8J308 |
| | DO 500 J=1,INNN | SS8J309 |
| | DO 500 K=3,4 | SS8J310 |
| | DO 500 I=1,3 | SS8J311 |
| 500 | EVAL(K,I,J,L) = 0.00 | SS8J312 |
| | RETURN | SS8J313 |
| | END | SS8J314 |

CC = 00315

| | | |
|------|--|---------|
| C ** | SUBROUTINE SEARCH (KEY1, KEY2, M1,M2,MM,KM,LM,IM,NM,FMIN) | SS8K000 |
| C ** | THIS SUBROUTINE KEEPS TRACK OF THE MINIMUM MARGIN OF SAFETY. | SS8K001 |
| C ** | | SS8K002 |
| | DIMENSION F(15,25,25) | SS8K003 |
| | COMMON / ARRAYS / F | SS8K004 |
| C | | SS8K005 |
| | FH = FMIN | SS8K006 |
| | DO 10 M=M1,M2 | SS8K007 |
| | DO 10 K=1,25 | SS8K008 |
| | DO 10 L=1,25 | SS8K009 |
| | IF (FH .LT. F(M,K,L)) GO TO 10 | SS8K010 |
| | FH = F(M,K,L) | SS8K011 |
| | MH = M | SS8K012 |
| | KH = K | SS8K013 |
| | LH = L | SS8K014 |
| 10 | CONTINUE | SS8K015 |
| | IF (FMIN .LE. FH) RETURN | SS8K016 |
| | FMIN = FH | SS8K017 |
| | MM = MH | SS8K018 |
| | KM = KH | SS8K019 |
| | LM = LH | SS8K020 |
| | IM = KEY1 | SS8K021 |
| | NM = KEY2 | SS8K022 |
| | RETURN | SS8K023 |
| | END | SS8K024 |
| | | SS8K025 |

CC = 00026

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SUBROUTINE ASEMBL
C
C ** THIS SUBROUTINE ASSEMBLES THE POTENTIAL ENERGY MATRIX ( V ),
C ** THE KINETIC ENERGY MATRIX ( TT ), THE EDGE LOADS MATRIX ( U ),
C ** AND THE LATERAL LOADS VECTOR ( Q ).
C
  DIMENSION V(150,150), TT(150,150), VHOLD(150,150)
  DIMENSION U(50,50), Q(150), S(150)
  DIMENSION QHOLD(150), SHOLD(150)
  DIMENSION AL(2,6,3,10,3,10), EVAL(4,2,3,10,25),
1 $W(10,2,3,10,10), P(11,2,3,3,10)
  DIMENSION A(3,3), B(3,3), D(3,3)
  DIMENSION YBARS(100), ZBARS(100), AS(100),
1 XIYYS(100), XIYZS(100), XIZZS(100), ES(100),
2 GJS(100), RHOS(100), PAXS(100),
3 XBARR(50), ZBARR(50), AR(50),
4 XIXXR(50), XIXZR(50), XIZZR(50), ER(50),
5 GJR(50), RHOR(50), PAXR(50),
A PMASS(50), IPWW(50), IPWY(50),
B PX(10,10), PY(10,10), PXY(10,10),
C PC(50), IPXX(50), IPYY(50),
D FC(50), IFXX(50), IFYY(50),
E ITAGCM(50), QQ(10,10),
F PLMOM(50), ITAGLM(50), IDISLM(50),
G PKC(50), IGSPRX(50), IGSPRY(50),
H PLINE(50), IDISLS(50), ITAGLS(50)
  DIMENSION ITIME(12), TIME(50)
  DIMENSION X(50), Y(50)
C
  COMMON U
  COMMON / BLOCK / TT
  COMMON / ARRAYS / P, AL, $W
  COMMON / VALUES / EVAL
  COMMON / CNTROL / IFLAGD, IFLAGB, IFLAGW, IBCX, IBCY,
1 N1, IEDGE, IREACT, N2(3), IELAST, INTprt
  COMMON / NUMBER / NPLYS, NTUX, NTVX, NTWX, NTUY,
1 NTVY, NTWY, NMODES, NSTRNG, NRING,
2 NPNX, NPNY, NQTX, NQTY, NPTLDS,
3 NPTMOM, NLNMOM, NLMASS, NPTSUP, NLNSPR,
4 MATSIZ, MUVSIZ, MWSIZ
  COMMON / GEOM / AA, BB, RR, ALFAX, ALFAY,
1 BETAX, BETAY
  COMMON / $TIME / TIME, ITIME
  COMMON / ABD / A, B, D, RHAB
  COMMON / PARAM / YBARS, ZBARS, AS, XIYYS, XIYZS,
1 XIZZS, ES, GJS, RHOS, PAXS,
3 XBARR, ZBARR, AR, XIXXR, XIXZR,
4 XIZZR, ER, GJR, RHOR, PAXR,
6 PMASS, IPWW, IPWY, PX, PY,
7 PXY, PC, IPXX, IPYY, FC,
8 IFXX, IFYY, ITAGCM, QQ, PLMOM,
9 ITAGLM, IDISLM, PKC, IGSPRX, IGSPRY,
A PLINE, IDISLS, ITAGLS
  COMMON / STFVAL / ESV(10,100), ESW(10,100), ESDW(10,100),
1 ERU(10,50), ERW(10,50), ERDW(10,50)
  EQUIVALENCE ( VHOLD(1),P(1) )

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| | |
|---|---------|
| EQUIVALENCE (QHOLD(1), YBARS(1)), (SHOLD(1), ZBARS(51)) | SS8L056 |
| DATA NAMEV/'V' '/' ,NAMETT/'TT' '/' ,NAMEU/'U' '/' ,NAMEQ/'Q' '/' | SS8L057 |
| DATA NAMES / 'S' ' / | SS8L058 |
| C | SS8L059 |
| ITHERY = 2 | SS8L060 |
| IF (INTPT .NE. 1) GO TO 1001 | SS8L061 |
| IF (ITHERY .EQ. 1) WRITE (6,11) | SS8L062 |
| 11 FORMAT ('O USING NOVOZHILOV SHELL THEORY') | SS8L063 |
| IF (ITHERY .EQ. 2) WRITE (6,12) | SS8L064 |
| 12 FORMAT ('O USING VLASOV SHELL THEORY') | SS8L065 |
| WRITE (6,4) | SS8L066 |
| 4 FORMAT ('OTHE AL INTEGRALS FOLLOW') | SS8L067 |
| DO 990 I=1,2 | SS8L068 |
| DO 990 I1=1,3 | SS8L069 |
| DO 900 J1=1,3 | SS8L070 |
| IF (I .EQ. 2) GO TO 7 | SS8L071 |
| IF (I1 .EQ. 1) M1L = NTUX | SS8L072 |
| IF (I1 .EQ. 2) M1L = NTVX | SS8L073 |
| IF (I1 .EQ. 3) M1L = NTWX | SS8L074 |
| IF (J1 .EQ. 1) M2L = NTUX | SS8L075 |
| IF (J1 .EQ. 2) M2L = NTVX | SS8L076 |
| IF (J1 .EQ. 3) M2L = NTWX | SS8L077 |
| GO TO 8 | SS8L078 |
| 7 IF (I1 .EQ. 1) M1L = NTUY | SS8L079 |
| IF (I1 .EQ. 2) M1L = NTVY | SS8L080 |
| IF (I1 .EQ. 3) M1L = NTWY | SS8L081 |
| IF (J1 .EQ. 1) M2L = NTUY | SS8L082 |
| IF (J1 .EQ. 2) M2L = NTVY | SS8L083 |
| IF (J1 .EQ. 3) M2L = NTWY | SS8L084 |
| 8 CONTINUE | SS8L085 |
| DO 3 K1=1,6 | SS8L086 |
| WRITE (6,1) I,K1,I1,J1 | SS8L087 |
| 1 FORMAT ('O',4I2) | SS8L088 |
| DO 3 M1=1,M1L | SS8L089 |
| WRITE (6,2) (AL(I,K1,I1,M1,J1,M2), M2=1,M2L) | SS8L090 |
| 2 FORMAT (' ',1P10E12.5) | SS8L091 |
| 3 CONTINUE | SS8L092 |
| 930 CONTINUE | SS8L093 |
| DO 930 ID1=1,4 | SS8L094 |
| WRITE (6,931) ID1,I,I1 | SS8L095 |
| 931 FORMAT ('O EVAL ',3I2) | SS8L096 |
| DO 930 LL=1,25 | SS8L097 |
| 930 WRITE (6,2) (EVAL(ID1,I,I1,M1,LL), M1=1,M1L) | SS8L098 |
| IF (I.EQ.1) MAXP = MAXO (NPNX,NQTX,1) | SS8L099 |
| IF (I.EQ.2) MAXP = MAXO (NPNY,NQTY,1) | SS8L100 |
| DO 940 IP=1,MAXP | SS8L101 |
| DO 940 K2=1,3 | SS8L102 |
| WRITE(6,941) IP,I,K2,I1 | SS8L103 |
| 941 FORMAT ('OP INTEGRALS ',4I2) | SS8L104 |
| 940 WRITE (6,2) (P(IP,I,K2,I1,M1), M1=1,M1L) | SS8L105 |
| 990 CONTINUE | SS8L106 |
| WRITE (6,901) | SS8L107 |
| 901 FORMAT ('OTHE W**2 INTEGRALS FOLLOW') | SS8L108 |
| DO 920 I=1,2 | SS8L109 |
| IF (I.EQ.2) GO TO 902 | SS8L110 |
| MAXP = MAXO (NPNX,NQTX,1) | SS8L111 |

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|--|---------|
| M3L = NTWX | SS8L112 |
| L3L = NTWX | SS8L113 |
| GO TO 903 | SS8L114 |
| 902 MAXP = MAXO (NPNY,NQTY,1) | SS8L115 |
| M3L = NTWY | SS8L116 |
| L3L = NTWY | SS8L117 |
| 903 DO 920 IP=1,MAXP | SS8L118 |
| DO 920 K2=1,3 | SS8L119 |
| WRITE (6,1) IP,I,K2 | SS8L120 |
| DO 920 L3=1,L3L | SS8L121 |
| 920 WRITE (6,2) (\$W(IP,I,K2,L3,M3),M3=1,M3L) | SS8L122 |
| 1001 CONTINUE | SS8L123 |
| DO 5 I=1,50 | SS8L124 |
| X(I)=0. | SS8L125 |
| 5 Y(I)=0. | SS8L126 |
| DO 6 I=1,MWSIZ | SS8L127 |
| DO 6 J=1,MWSIZ | SS8L128 |
| 6 U(I,J) = 0. | SS8L129 |
| DO 10 I = 1,MATSIZ | SS8L130 |
| Q(I) = 0. | SS8L131 |
| S(I) = 0. | SS8L132 |
| DO 10 J = 1,MATSIZ | SS8L133 |
| V(I,J) = 0. | SS8L134 |
| TT(I,J) = 0. | SS8L135 |
| 10 CONTINUE | SS8L136 |
| L = 1 | SS8L137 |
| K = 1 | SS8L138 |
| A1 = 1./AA | SS8L139 |
| B1 = 1./BB | SS8L140 |
| R1 = 1./RR | SS8L141 |
| A1B = A1*BB | SS8L142 |
| AB1 = AA*B1 | SS8L143 |
| A1BR1 = A1B*R1 | SS8L144 |
| AB1R1 = AB1*R1 | SS8L145 |
| BR1 = BB*R1 | SS8L146 |
| AR1 = AA*R1 | SS8L147 |
| A2B = A1B*A1 | SS8L148 |
| AB2 = AB1*B1 | SS8L149 |
| B1R2 = B1*R1*R1 | SS8L150 |
| R2 = R1*R1 | SS8L151 |
| BR2 = BR1*R1 | SS8L152 |
| AR2 = AR1*R1 | SS8L153 |
| A1R1 = A1*R1 | SS8L154 |
| A2BR1 = A2B*R1 | SS8L155 |
| AB2R1 = AB2*R1 | SS8L156 |
| B1R1 = B1*R1 | SS8L157 |
| TBR2 = 2.*BR2 | SS8L158 |
| ABR2 = AA*BR2 | SS8L159 |
| A3B = A2B/AA | SS8L160 |
| A1B1 = A1*B1 | SS8L161 |
| A2 = A1*A1 | SS8L162 |
| AB3 = AB2/BB | SS8L163 |
| B2 = B1*B1 | SS8L164 |
| B3 = B2*B1 | SS8L165 |
| AB = AA*BB | SS8L166 |
| A1B1R1 = A1*B1R1 | SS8L167 |

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|--|---------|
| A1B2 = A1B1*B1 | SS8L168 |
| A2B1 = A1*A1B1 | SS8L169 |
| A3 = A1*A2 | SS8L170 |
| AB1R2 = AB1*R2 | SS8L171 |
| A1BR2 = A1B*R2 | SS8L172 |
| A2BR2 = A2B*R2 | SS8L173 |
| ABR1 = AA*BR1 | SS8L174 |
| AR3 = AR2 * R1 | SS8L175 |
| BR3 = BR2 * R1 | SS8L176 |
| ABR3 = ABR2 * R1 | SS8L177 |
| ABR4 = ABR3 * R1 | SS8L178 |
| CALL STATUS (ITIME) | SS8L179 |
| TIME(5) = .01*ITIME(8) | SS8L180 |
| DO 1000 IP = 1,3 | SS8L181 |
| DO 1000 IQ = 1,3 | SS8L182 |
| IF (IP .EQ. 1) NTLI = NTUX | SS8L183 |
| IF (IP .EQ. 1) NTLJ = NTUY | SS8L184 |
| IF (IP .EQ. 2) NTLI = NTVX | SS8L185 |
| IF (IP .EQ. 2) NTLJ = NTVY | SS8L186 |
| IF (IP .EQ. 3) NTLI = NTWX | SS8L187 |
| IF (IP .EQ. 3) NTLJ = NTWY | SS8L188 |
| IF (IQ .EQ. 1) NTLM = NTUX | SS8L189 |
| IF (IQ .EQ. 1) NTLN = NTUY | SS8L190 |
| IF (IQ .EQ. 2) NTLM = NTVX | SS8L191 |
| IF (IQ .EQ. 2) NTLN = NTVY | SS8L192 |
| IF (IQ .EQ. 3) NTLM = NTWX | SS8L193 |
| IF (IQ .EQ. 3) NTLN = NTWY | SS8L194 |
| DO 1000 I = 1,NTLI | SS8L195 |
| DO 1000 J = 1,NTLJ | SS8L196 |
| DO 1000 M = 1,NTLM | SS8L197 |
| DO 1000 N = 1,NTLN | SS8L198 |
| IF (IP .EQ. 1) II = (I-1)*NTUY + J | SS8L199 |
| IF (IP .EQ. 2) II = NTUX*NTUY + (I-1)*NTVY + J | SS8L200 |
| IF (IP .EQ. 3) II = NTUX*NTUY + NTVX*NTVY + (I-1)*NTWY + J | SS8L201 |
| IF (IQ .EQ. 1) JJ = (M-1)*NTUY + N | SS8L202 |
| IF (IQ .EQ. 2) JJ = NTUX*NTUY + (M-1)*NTVY + N | SS8L203 |
| IF (IQ .EQ. 3) JJ = NTUX*NTUY + NTVX*NTVY + (M-1)*NTWY + N | SS8L204 |
| KK = II -MUVSIZ | SS8L205 |
| LL = JJ -MUVSIZ | SS8L206 |
| IF (IP .GT. IQ) GO TO 580 | SS8L207 |
| IF (IP .EQ. 1 .AND. IQ .EQ. 1) GO TO 20 | SS8L208 |
| IF (IP .EQ. 1 .AND. IQ .EQ. 2) GO TO 100 | SS8L209 |
| IF (IP .EQ. 1 .AND. IQ .EQ. 3) GO TO 160 | SS8L210 |
| IF (IP .EQ. 2 .AND. IQ .EQ. 2) GO TO 220 | SS8L211 |
| IF (IP .EQ. 2 .AND. IQ .EQ. 3) GO TO 310 | SS8L212 |
| IF (IP .EQ. 3 .AND. IQ .EQ. 3) GO TO 370 | SS8L213 |
| 20 X(1) = AL(1,2,1,I,1,M) * AL(2,1,1,J,1,N) | SS8L214 |
| X(2) = AL(1,4,1,I,1,M) * AL(2,4,1,N,1,J) | SS8L215 |
| X(3) = AL(1,4,1,M,1,I) * AL(2,4,1,J,1,N) | SS8L216 |
| X(4) = AL(1,1,1,I,1,M) * AL(2,2,1,J,1,N) | SS8L217 |
| Y(1) = A(1,1) * A1B * X(1) + A(1,3) * (X(2) + X(3)) | SS8L218 |
| 1 + A(3,3) * AB1 * X(4) | SS8L219 |
| V(II,JJ) = V(II,JJ) + Y(1) | SS8L220 |
| IF (ITHERY .EQ. 2) V(II,JJ) = V(II,JJ) - B(1,3) * R1 * (X(2) | SS8L221 |
| 1 + X(3)) - 2.* B(3,3) * AB1R1 * X(4) + D(3,3) * AB1R2 * X(4) | SS8L222 |
| IF (NSTRNG .EQ. 0) GO TO 30 | SS8L223 |

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| DO 30 L=1,NSTRNG | SS8L224 |
| V(II,JJ) = V(II,JJ) + A1 * ES(L) * AS(L) * AL(1,2,1,I,1,M) | SS8L225 |
| 1 * ESW(J,L) * ESW(N,L) | SS8L226 |
| 30 CONTINUE | SS8L227 |
| IF (NRING .EQ. 0) GO TO 40 | SS8L228 |
| DO 40 K=1,NRING | SS8L229 |
| V(II,JJ) = V(II,JJ) + B3 * ER(K) * XIZZR(K) * AL(2,3,1,J,1,N) | SS8L230 |
| 1 * ERU(I,K) * ERU(M,K) | SS8L231 |
| 40 CONTINUE | SS8L232 |
| IF (IFLAGD .EQ. 0) GO TO 70 | SS8L233 |
| TT(II,JJ) = RHAB * AL(1,1,1,I,1,M) * AL(2,1,1,J,1,N) | SS8L234 |
| IF (NSTRNG .EQ. 0) GO TO 50 | SS8L235 |
| DO 50 L=1,NSTRNG | SS8L236 |
| TT(II,JJ) = TT(II,JJ) + RHOS(L) * AS(L) * AL(1,1,1,I,1,M) * AA | SS8L237 |
| 1 * ESW(J,L) * ESW(N,L) | SS8L238 |
| 50 CONTINUE | SS8L239 |
| IF (NRING .EQ. 0) GO TO 60 | SS8L240 |
| DO 60 K=1,NRING | SS8L241 |
| TT(II,JJ) = TT(II,JJ) + RHOR(K) * (BB * AR(K) * AL(2,1,1,J,1,N) | SS8L242 |
| 1 + XIZZR(K) * B1 * AL(2,2,1,J,1,N)) | SS8L243 |
| 2 * ERU(I,K) * ERU(M,K) | SS8L244 |
| 60 CONTINUE | SS8L245 |
| IF (NLMASS .EQ. 0) GO TO 70 | SS8L246 |
| DO 70 L=1,NLMASS | SS8L247 |
| TT(II,JJ) = TT(II,JJ) + PMASS(L) * EVAL(1,1,1,I,IPWW(L)) * | SS8L248 |
| 1EVAL(1,2,1,J,IPWY(L))*EVAL(1,1,1,M,IPWW(L))*EVAL(1,2,1,N,IPWY(L)) | SS8L249 |
| 70 CONTINUE | SS8L250 |
| IF (IFLAGW .EQ. 0) GO TO 1000 | SS8L251 |
| IF (JJ .GT. 1) GO TO 1000 | SS8L252 |
| IF (IEDGE .EQ. 0) GO TO 75 | SS8L253 |
| IF (NSTRNG .EQ. 0) GO TO 72 | SS8L254 |
| DO 72 L=1,NSTRNG | SS8L255 |
| S(II) = S(II) - PAXS(L) * P(1,1,2,1,I) * ESW(J,L) | SS8L256 |
| 72 CONTINUE | SS8L257 |
| IF (NRING .EQ. 0) GO TO 73 | SS8L258 |
| DO 73 K=1,NRING | SS8L259 |
| S(II) = S(II) - PAXR(K) * XBARR(K) * P(1,2,3,1,J) * ERU(I,K) | SS8L260 |
| 73 CONTINUE | SS8L261 |
| DO 74 K=1,NPNX | SS8L262 |
| DO 74 L=1,NPNY | SS8L263 |
| 74 S(II) = S(II) - BB * PX (K,L) * P(K,1,2,1,I) * P(L,2,1,1,J) | SS8L264 |
| 1 - AA * PXY(K,L) * P(K,1,1,1,I) * P(L,2,2,1,J) | SS8L265 |
| 75 IF (NPTMOM .EQ. 0) GO TO 80 | SS8L266 |
| DO 80 L=1,NPTMOM | SS8L267 |
| IF (ITAGCM(L) .EQ. 1) GO TO 80 | SS8L268 |
| Q(II) = Q(II) - R1 * FC(L) * EVAL(1,1,1,I,IFXX(L)) | SS8L269 |
| 1 * EVAL(1,2,1,J,IFYY(L)) | SS8L270 |
| 80 CONTINUE | SS8L271 |
| IF (NLNMOM .EQ. 0) GO TO 1000 | SS8L272 |
| DO 90 L=1,NLNMOM | SS8L273 |
| IF (ITAGLM(L) .EQ. 1) GO TO 90 | SS8L274 |
| Q(II) = Q(II) - BR1 * PLMOM(L) * EVAL(1,1,1,I,IDISLM(L)) | SS8L275 |
| 1 * P(1,2,1,1,J) | SS8L276 |
| 90 CONTINUE | SS8L277 |
| GO TO 1000 | SS8L278 |
| 100 X(5) = AL(1,4,1,I,2,M) * AL(2,4,2,N,1,J) | SS8L279 |

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X( 6) = AL(1,2,1,I,2,M) * AL(2,1,1,J,2,N) SS8L280
X( 7) = AL(1,1,1,I,2,M) * AL(2,2,1,J,2,N) SS8L281
X( 8) = AL(1,4,2,M,1,I) * AL(2,4,1,J,2,N) SS8L282
Y( 2) = A(1,2) * X( 5) + A(1,3) * A1B * X( 6) SS8L283
1 + A(2,3) * AB1 * X( 7) + A(3,3) * X( 8) SS8L284
IF ( ITHERY .NE. 1 ) GO TO 105 SS8L285
Y( 3) = B(1,2) * R1 * X( 5) + 2. * B(1,3) * A1BR1 * X( 6) SS8L286
1 + B(2,3) * AB1R1 * X( 7) + 2. * B(3,3) * R1 * X( 8) SS8L287
GO TO 110 SS8L288
105 Y(3) = B(1,3) * A1BR1 * X(6) - B(2,3) * AB1R1 * X(7) SS8L289
1 - D(3,3) * R2 * X(8) SS8L290
110 V(II,JJ) = V(II,JJ) + Y(2) + Y(3) SS8L291
IF ( NSTRNG .EQ. 0 ) GO TO 120 SS8L292
DO 120 L=1,NSTRNG SS8L293
V(II,JJ) = V(II,JJ) - A2 * ES(L) * AS(L) * YBARS(L) SS8L294
1 * AL(1,6,2,M,1,I) * ESW(J,L) * ESV(N,L) SS8L295
120 CONTINUE SS8L296
IF ( NRING .EQ. 0 ) GO TO 130 SS8L297
DO 130 K=1,NRING SS8L298
V(II,JJ) = V(II,JJ) - B2 * ER(K) * AR(K) * XBAKR(K) SS8L299
2 * AL(2,6,1,J,2,N) * ERU(I,K) * ERW(M,K) SS8L300
130 CONTINUE SS8L301
IF ( IFLAGD .EQ. 0 ) GO TO 1000 SS8L302
IF ( NSTRNG .EQ. 0 ) GO TO 140 SS8L303
DO 140 L=1,NSTRNG SS8L304
TT(II,JJ) = TT(II,JJ) - RHOS(L) * AS(L) * YBARS(L) SS8L305
1 * AL(1,4,2,M,1,I) * ESW(J,L) * ESV(N,L) SS8L306
140 CONTINUE SS8L307
IF ( NRING .EQ. 0 ) GO TO 1000 SS8L308
DO 150 K=1,NRING SS8L309
TT(II,JJ) = TT(II,JJ) - RHOR(K) * AR(K) * XBARR(K) SS8L310
2 * AL(2,4,1,J,2,N) * ERU(I,K) * ERW(M,K) SS8L311
150 CONTINUE SS8L312
GO TO 1000 SS8L313
160 X( 9) = AL(1,4,1,I,3,M) * AL(2,1,1,J,3,N) SS8L314
X(10) = AL(1,1,1,I,3,M) * AL(2,4,1,J,3,N) SS8L315
X(11) = AL(1,6,3,M,1,I) * AL(2,1,1,J,3,N) SS8L316
X(12) = AL(1,4,1,I,3,M) * AL(2,5,3,N,1,J) SS8L317
X(13) = AL(1,2,1,I,3,M) * AL(2,4,3,N,1,J) SS8L318
X(14) = AL(1,5,3,M,1,I) * AL(2,4,1,J,3,N) SS8L319
X(15) = AL(1,1,1,I,3,M) * AL(2,6,3,N,1,J) SS8L320
X(16) = AL(1,4,3,M,1,I) * AL(2,2,1,J,3,N) SS8L321
Y( 4) = A(1,2) * BR1 * X( 9) + A(2,3) * AR1 * X(10) SS8L322
IF ( ITHERY .NE. 1 ) GO TO 165 SS8L323
Y( 5) = -B(1,1) * A2B * X(11) - B(1,2) * B1 * X(12) SS8L324
1 - B(1,3) * A1 * ( 2. * X(13) + X(14) ) SS8L325
2 - B(2,3) * AB2 * X(15) - 2. * B(3,3) * B1 * X(16) SS8L326
GO TO 170 SS8L327
165 Y(5) = - B(1,1) * A2B * X(11) - B(1,2) * ( BR2 * X(9) + B1 * X(12) ) SS8L328
1 - B(1,3) * A1 * ( 2.*X(13) + X(14) ) - B(2,3) * ( 2. * AR2 SS8L329
2 * X(10) + AB2 * X(15) ) - 2.* B(3,3) * B1 * X(16) SS8L330
3 + D(1,3) * A1R1 * X(14) + D(2,3) * ( AR3 * X(10) SS8L331
4 + AB2R1 * X(15) ) + 2.* D(3,3) * B1R1 * X(16) SS8L332
170 V(II,JJ) = V(II,JJ) + Y(4) + Y(5) SS8L333
IF ( NSTRNG .EQ. 0 ) GO TO 180 SS8L334
DO 180 L=1,NSTRNG SS8L335

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| V(II,JJ) = V(II,JJ) - ES(L) * AS(L) * ZBARS(L) * A2 | SS8L336 |
| 1 * AL(1,6,3,M,1,I) * ESW(J,L) * ESW(N,L) | SS8L337 |
| 180 CONTINUE | SS8L338 |
| IF (NRING .EQ. 0) GO TO 190 | SS8L339 |
| DO 190 K=1,NRING | SS8L340 |
| V(II,JJ) = V(II,JJ) + ERU(I,K) * ER(K) * (ERW(M,K) * (XIXZR(K) | SS8L341 |
| 1 * B3 * AL(2,3,1,J,3,N) - AR(K) * XBARR(K) * B1R1 | SS8L342 |
| 2 * AL(2,5,1,J,3,N)) - XIZZR(K) * A1B1R1 * ERDW(M,K) | SS8L343 |
| 3 * AL(2,5,1,J,3,N)) | SS8L344 |
| 190 CONTINUE | SS8L345 |
| IF (IFLAGD .EQ. 0) GO TO 1000 | SS8L346 |
| IF (NSTRNG .EQ. 0) GO TO 200 | SS8L347 |
| DO 200 L=1,NSTRNG | SS8L348 |
| TT(II,JJ) = TT(II,JJ) - RHOS(L) * AS(L) * ZBARS(L) | SS8L349 |
| 1 * AL(1,4,3,M,1,I) * ESW(J,L) * ESW(N,L) | SS8L350 |
| 200 CONTINUE | SS8L351 |
| IF (NRING .EQ. 0) GO TO 1000 | SS8L352 |
| DO 210 K=1,NRING | SS8L353 |
| TT(II,JJ) = TT(II,JJ) + RHOR(K) * ERU(I,K) * (-ZBARR(K) * A1B | SS8L354 |
| 1 * AR(K) * ERDW(M,K) * AL(2,1,1,J,3,N) + B1 * XIXZR(K) | SS8L355 |
| 2 * AL(2,2,1,J,3,N) * ERW(M,K)) | SS8L356 |
| 210 CONTINUE | SS8L357 |
| GO TO 1000 | SS8L358 |
| 220 X(17) = AL(1,1,2,I,2,M) * AL(2,2,2,J,2,N) | SS8L359 |
| X(18) = AL(1,4,2,I,2,M) * AL(2,4,2,N,2,J) | SS8L360 |
| X(19) = AL(1,4,2,M,2,I) * AL(2,4,2,J,2,N) | SS8L361 |
| X(20) = AL(1,2,2,I,2,M) * AL(2,1,2,J,2,N) | SS8L362 |
| Y(6) = A(2,2) * AB1 * X(17) + A(2,3) * (X(18) + X(19)) | SS8L363 |
| 1 + A(3,3) * A1B * X(20) | SS8L364 |
| IF (ITHERY .NE. 1) GO TO 225 | SS8L365 |
| Y(7) = 2. * B(2,2) * AB1R1 * X(17) + 3. * B(2,3) * R1 * (X(18) | SS8L366 |
| 1 + X(19)) + 4. * B(3,3) * A1BR1 * X(20) | SS8L367 |
| Y(8) = D(2,2) * AB1R2 * X(17) + 2. * D(2,3) * R2 * (X(18)+X(19)) | SS8L368 |
| 1 + 4. * D(3,3) * A1BR2 * X(20) | SS8L369 |
| GO TO 230 | SS8L370 |
| 225 Y(7) = B(2,3) * R1 * (X(18) + X(19)) + 2. * B(3,3)*A1BR1*X(20) | SS8L371 |
| Y(8) = D(3,3) * A1BR2 * X(20) | SS8L372 |
| 230 V(II,JJ) = V(II,JJ) + Y(6) + Y(7) + Y(8) | SS8L373 |
| IF (NSTRNG .EQ. 0) GO TO 240 | SS8L374 |
| DO 240 L=1,NSTRNG | SS8L375 |
| V(II,JJ) = V(II,JJ) + ES(L) * XIZZS(L) * A3 * AL(1,3,2,I,2,M) | SS8L376 |
| 1 * ESV(J,L) * ESV(N,L) | SS8L377 |
| 240 CONTINUE | SS8L378 |
| IF (NRING .EQ. 0) GO TO 250 | SS8L379 |
| DO 250 K=1,NRING | SS8L380 |
| V(II,JJ) = V(II,JJ) + ER(K) * AR(K) * B1 * AL(2,2,2,J,2,N) | SS8L381 |
| 1 * ERW(I,K) * ERW(M,K) | SS8L382 |
| 250 CONTINUE | SS8L383 |
| IF (IFLAGD .EQ. 0) GO TO 280 | SS8L384 |
| TT(II,JJ) = TT(II,JJ) + RHAB * AL(1,1,2,I,2,M) * AL(2,1,2,J,2,N) | SS8L385 |
| IF (NSTRNG .EQ. 0) GO TO 260 | SS8L386 |
| DO 260 L=1,NSTRNG | SS8L387 |
| TT(II,JJ) = TT(II,JJ) + RHOS(L) * ESV(J,L)*ESV(N,L)*(AA*AS(L) | SS8L388 |
| 2 * AL(1,1,2,I,2,M) + A1 * XIZZS(L) * AL(1,2,2,I,2,M)) | SS8L389 |
| 260 CONTINUE | SS8L390 |
| IF (NRING .EQ. 0) GO TO 270 | SS8L391 |

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| DO 270 K=1,NRING | SS8L392 |
| TT(II,JJ) = TT(II,JJ) + RHOR(K) * AR(K) * BB * AL(2,1,2,J,2,N) | SS8L393 |
| 1 * ERW(I,K) * ERW(M,K) | SS8L394 |
| 270 CONTINUE | SS8L395 |
| IF (NLMASS .EQ. 0) GO TO 280 | SS8L396 |
| DO 280 K=1,NLMASS | SS8L397 |
| TT(II,JJ) = TT(II,JJ) + PMASS(K) * EVAL(1,1,2,I,IPWW(K)) * | SS8L398 |
| 1EVAL(1,2,2,J,IPWY(K))*EVAL(1,1,2,M,IPWW(K))*EVAL(1,2,2,N,IPWY(K)) | SS8L399 |
| 280 CONTINUE | SS8L400 |
| IF (IFLAGW .EQ. 0) GO TO 1000 | SS8L401 |
| IF (JJ .GT. NTUX*NTUY + 1) GO TO 1000 | SS8L402 |
| IF (IEDGE .EQ. 0) GO TO 285 | SS8L403 |
| IF (NSTRNG .EQ. 0) GO TO 282 | SS8L404 |
| DO 282 L=1,NSTRNG | SS8L405 |
| S(II) = S(II) + PAXS(L) * A1 * YBARS(L) * P(1,1,3,2,I)*ESV(J,L) | SS8L406 |
| 282 CONTINUE | SS8L407 |
| IF (NRING .EQ. 0) GO TO 283 | SS8L408 |
| DO 283 K=1,NRING | SS8L409 |
| S(II) = S(II) - PAXR(K) * P(1,2,2,2,J) * ERW(I,K) | SS8L410 |
| 283 CONTINUE | SS8L411 |
| DO 284 K=1,NPNX | SS8L412 |
| DO 284 L=1,NPNY | SS8L413 |
| 284 S(II) = S(II) - AA * PY (K,L) * P(K,1,1,2,I) * P(L,2,2,2,J) | SS8L414 |
| 1 - BB * PXY(K,L) * P(K,1,2,2,I) * P(L,2,1,2,J) | SS8L415 |
| 285 IF (NPTMOM .EQ. 0) GO TO 290 | SS8L416 |
| DO 290 K=1,NPTMOM | SS8L417 |
| IF (ITAGCM(K) .EQ. 2) GO TO 290 | SS8L418 |
| Q(II) = Q(II) - R1 * FC(K) * EVAL(1,1,2,I,IFXX(K)) | SS8L419 |
| 1 * EVAL(1,2,2,J,IFY(Y(K)) | SS8L420 |
| 290 CONTINUE | SS8L421 |
| IF (NLNMOM .EQ. 0) GO TO 1000 | SS8L422 |
| DO 300 K=1,NLNMOM | SS8L423 |
| IF (ITAGLM(K) .EQ. 2) GO TO 300 | SS8L424 |
| Q(II) = Q(II) - AR1 * PLMOM(K) * EVAL(1,2,2,J,IDISLM(K)) | SS8L425 |
| 1 * P(1,1,1,2,I) | SS8L426 |
| 300 CONTINUE | SS8L427 |
| GO TO 1000 | SS8L428 |
| 310 X(21) = AL(1,1,2,I,3,M) * AL(2,4,2,J,3,N) | SS8L429 |
| X(22) = AL(1,4,2,I,3,M) * AL(2,1,2,J,3,N) | SS8L430 |
| X(23) = AL(1,5,3,M,2,I) * AL(2,4,2,J,3,N) | SS8L431 |
| X(24) = AL(1,6,3,M,2,I) * AL(2,1,2,J,3,N) | SS8L432 |
| X(25) = AL(1,4,3,M,2,I) * AL(2,2,2,J,3,N) | SS8L433 |
| X(26) = AL(1,4,2,I,3,M) * AL(2,5,3,N,2,J) | SS8L434 |
| X(27) = AL(1,2,2,I,3,M) * AL(2,4,3,N,2,J) | SS8L435 |
| X(28) = AL(1,1,2,I,3,M) * AL(2,6,3,N,2,J) | SS8L436 |
| Y(9) = A(2,2) * AR1 * X(21) + A(2,3) * BR1 * X(22) | SS8L437 |
| IF (ITHERY .NE. 1) GO TO 315 | SS8L438 |
| Y(10) = - B(1,2) * A1 * X(23) - B(1,3) * A2B * X(24) | SS8L439 |
| 1 + B(2,2) * (AR2 * X(21) - AB2 * X(28)) | SS8L440 |
| 2 + B(2,3) * (TBR2 * X(22) - 2. * B1 * X(25) - B1 * X(26)) | SS8L441 |
| 3 - B(3,3) * 2. * A1 * X(27) | SS8L442 |
| Y(11) = - D(1,2) * A1R1 * X(23) - 2. * D(1,3) * A2BR1 * X(24) | SS8L443 |
| 1 - D(2,2) * AB2R1 * X(28) - 2. * D(2,3) * B1R1 * (X(26) | SS8L444 |
| 2 + X(25)) - 4. * D(3,3) * A1R1 * X(27) | SS8L445 |
| GO TO 320 | SS8L446 |
| 315 Y(10) = - B(1,2) *A1 * X(23) - B(1,3) * A2B * X(24) | SS8L447 |

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1      - B(2,2) * ( AR2 * X(21) + AB2 * X(28) )      SS8L448
2      - B(2,3) * B1 * ( 2.*X(25) + X(26) )          SS8L449
3      - 2.*B(3,3) * A1 * X(27)                      SS8L450
Y(11) = - D(1,3) * A2BR1 * X(24) - D(2,3) * ( B1R1 * X(26)
1      + BR3 * X(22) ) - 2.*D(3,3) * A1R1 * X(27)    SS8L451
320 V(II,JJ) = V(II,JJ) + Y(9) + Y(10) + Y(11)      SS8L452
      IF ( NSTRNG .EQ. 0 ) GO TO 330                 SS8L453
      DO 330 L=1,NSTRNG                               SS8L454
      V(II,JJ) = V(II,JJ) + ES(L) * XIYZS(L) * A3 * AL(1,3,2,I,3,M)
1      * ESV(J,L) * ESW(N,L)                         SS8L455
330 CONTINUE                                          SS8L456
      IF ( NRING .EQ. 0 ) GO TO 340                   SS8L457
      DO 340 K=1,NRING                               SS8L458
      V(II,JJ) = V(II,JJ) + ER(K) * AR(K) * ERW(I,K) SS8L459
1      * ( ERW(M,K) * (-ZBARR(K) * B2                SS8L460
2      * AL(2,6,3,N,2,J) + R1 * AL(2,4,2,J,3,N) ) + XBARR(K)
3      * A1R1 * ERDW(M,K) * AL(2,4,2,J,3,N) )        SS8L461
340 CONTINUE                                          SS8L462
      IF ( IFLAGD .EQ. 0 ) GO TO 1000                 SS8L463
      IF ( NSTRNG .EQ. 0 ) GO TO 350                 SS8L464
      DO 350 L=1,NSTRNG                               SS8L465
      TT(II,JJ) = TT(II,JJ) + RHDS(L) * ESV(J,L)     SS8L466
1      * ( - AB1 * ZBARS(L) * AS(L) * AL(1,1,2,I,3,M) SS8L467
2      * ESDW(N,L) + A1 * XIYYS(L)                   SS8L468
3      * AL(1,2,2,I,3,M) * ESW(N,L) )                SS8L469
350 CONTINUE                                          SS8L470
      IF ( NRING .EQ. 0 ) GO TO 1000                 SS8L471
      DO 360 K=1,NRING                               SS8L472
      TT(II,JJ) = TT(II,JJ) - RHDR(K) * AR(K) * ZBARR(K)
2      * AL(2,4,3,N,2,J) * ERW(I,K) * ERW(M,K)      SS8L473
360 CONTINUE                                          SS8L474
      GO TO 1000                                       SS8L475
370 X(29) = AL(1,1,3,I,3,M) * AL(2,1,3,J,3,N)      SS8L476
      X(30) = AL(1,5,3,I,3,M) * AL(2,1,3,J,3,N)      SS8L477
      X(31) = AL(1,5,3,M,3,I) * AL(2,1,3,J,3,N)      SS8L478
      X(32) = AL(1,1,3,I,3,M) * AL(2,5,3,N,3,J)      SS8L479
      X(33) = AL(1,1,3,I,3,M) * AL(2,5,3,N,3,J)      SS8L480
      X(34) = AL(1,4,3,M,3,I) * AL(2,4,3,N,3,J)      SS8L481
      X(35) = AL(1,4,3,I,3,M) * AL(2,4,3,J,3,N)      SS8L482
      X(36) = AL(1,3,3,I,3,M) * AL(2,1,3,J,3,N)      SS8L483
      X(37) = AL(1,5,3,M,3,I) * AL(2,5,3,J,3,N)      SS8L484
      X(38) = AL(1,5,3,I,3,M) * AL(2,5,3,N,3,J)      SS8L485
      X(39) = AL(1,6,3,M,3,I) * AL(2,4,3,J,3,N)      SS8L486
      X(40) = AL(1,6,3,I,3,M) * AL(2,4,3,N,3,J)      SS8L487
      X(41) = AL(1,1,3,I,3,M) * AL(2,3,3,J,3,N)      SS8L488
      X(42) = AL(1,4,3,M,3,I) * AL(2,6,3,J,3,N)      SS8L489
      X(43) = AL(1,4,3,I,3,M) * AL(2,6,3,N,3,J)      SS8L490
      X(44) = AL(1,2,3,I,3,M) * AL(2,2,3,J,3,N)      SS8L491
      Y(12) = A(2,2) * ABR2 * X(29)                  SS8L492
      IF ( ITHRY .NE. 1 ) GO TO 375                  SS8L493
      Y(13) = -B(1,2) * A1BR1 * ( X(30) + X(31) )    SS8L494
1      - B(2,2) * AB1R1 * ( X(32) + X(33) )          SS8L495
2      - B(2,3) * 2.*R1 * ( X(34) + X(35) )          SS8L496
      Y(14) = D(1,1) * A3B * X(36) + D(1,2) * A1B1 * ( X(37)+X(38) )
1      + D(1,3) * 2.*A2 * ( X(39)+X(40) ) + D(2,2) * AB3 * X(41)
2      + D(2,3) * 2.*B2 * ( X(42)+X(43) ) + D(3,3) * 4.*A1B1 * X(44)

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GO TO 379
375 Y(13) = - B(1,2) * A1BR1 * ( X(30) + X(31) ) - B(2,2) * AB1R1 *
1      ( X(32) + X(33) ) - 2.*B(2,2) * ABR3 * X(29)
2      - 2.*B(2,3)* R1 * ( X(34) + X(35) )
Y(14) = D(1,1) * A3B * X(36) + D(1,2) * A1B1 * ( X(37) + X(38) )
1      + D(1,2) * A1BR2 * ( X(30) + X(31) ) + 2.*D(1,3) * A2 *
2      ( X(39) + X(40) ) + D(2,2) * (AB3 * X(41) + ABR4 * X(29)
3      + AB1R2 * ( X(32) + X(33) ) ) + 2.*D(2,3) * ( B2 * ( X(42)
4      + X(43) ) + R2 * ( X(34) + X(35) ) ) + 4.*D(3,3)*A1B1*X(44)
379 V(II,JJ) = V(II,JJ) + Y(12) + Y(13) + Y(14)
IF ( NSTRNG .EQ. 0 ) GO TO 380
DO 380 L=1,NSTRNG
V(II,JJ) = V(II,JJ) + ES(L) * XIYYS(L) * A3 * AL(1,3,3,I,3,M)
1      * ESW(J,L) * ESW(N,L)
2      + GJS(L) * A1B2 * AL(1,2,3,I,3,M)
3      * ESDW(J,L) * ESDW(N,L)
380 CONTINUE
IF ( NRING .EQ. 0 ) GO TO 390
DO 390 K=1,NRING
V(II,JJ) = V(II,JJ) + ER(K) * XIXXR(K) * B3 * AL(2,3,3,J,3,N)
1      * ERW(I,K) * ERW(M,K)
2      + GJR(K) * A2B1 * AL(2,2,3,J,3,N)
3      * ERDW(I,K) * ERDW(M,K)
390 CONTINUE
IF ( IELAST .EQ. 1 ) GO TO 400
V(II,JJ) = V(II,JJ) + A3B * D(1,1) * AL(2,1,3,J,3,N) *
1      ( ALFAX * EVAL(2,1,3,I,1) * EVAL(2,1,3,M,1)
2      + BETAX * EVAL(2,1,3,I,25) * EVAL(2,1,3,M,25) )
3      + AB3 * D(2,2) * AL(1,1,3,I,3,M) *
4      ( ALFAY * EVAL(2,2,3,J,1) * EVAL(2,2,3,N,1)
5      + BETAY * EVAL(2,2,3,J,25) * EVAL(2,2,3,N,25) )
400 CONTINUE
IF ( NPTSUP .EQ. 0 ) GO TO 410
DO 410 L=1,NPTSUP
V(II,JJ) = V(II,JJ) + PKC(L)
1      * EVAL(1,1,3,I,IGSPRX(L)) * EVAL(1,1,3,M,IGSPRX(L))
2      * EVAL(1,2,3,J,IGSPRY(L)) * EVAL(1,2,3,N,IGSPRY(L))
410 CONTINUE
IF ( NLNSPR .EQ. 0 ) GO TO 430
DO 430 L=1,NLNSPR
IF ( ITAGLS(L) .EQ. 2 ) GO TO 420
V(II,JJ) = V(II,JJ) + PLINE(L) * AA * AL(1,1,3,I,3,M)
1      * EVAL(1,2,3,J,IDISLS(L)) * EVAL(1,2,3,N,IDISLS(L))
GO TO 430
420 V(II,JJ) = V(II,JJ) + PLINE(L) * BB * AL(2,1,3,J,3,N)
1      * EVAL(1,1,3,I,IDISLS(L)) * EVAL(1,1,3,M,IDISLS(L))
430 CONTINUE
IF ( NRING .EQ. 0 ) GO TO 450
DO 450 K=1,NRING
V(II,JJ) = V(II,JJ) + ER(K) * ( ERW(I,K) * ( AR(K)
1      * ERW(M,K) * ( BR2 * AL(2,1,3,J,3,N)
2      - ZBARR(K) * B1R1 * ( AL(2,5,3,J,3,N) + AL(2,5,3,N,3,J) ) )
3      + ERDW(M,K) * ( - XIXZR(K) * A1B1R1*AL(2,5,3,J,3,N)
4      + AR(K) * XBARR(K) * A1BR2 * AL(2,1,3,J,3,N) ) )
5      + ERDW(I,K) * ( ERW(M,K) * ( - XIXZR(K)
6      * A1B1R1 * AL(2,5,3,N,3,J) + AR(K) * XBARR(K) * A1BR2

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7          * AL(2,1,3,J,3,N) ) + ERDW(M,K)          * XIZZR(K)          SS8L560
8          * A2BR2 * AL(2,1,3,J,3,N) ) )          SS8L561
450 CONTINUE          SS8L562
   IF ( IFLAGD .EQ. 0 ) GO TO 480          SS8L563
   TT(II,JJ) = TT(II,JJ) + RHAB * AL(1,1,3,I,3,M) * AL(2,1,3,J,3,N)          SS8L564
   IF ( NSTRNG .EQ. 0 ) GO TO 460          SS8L565
   DO 460 L=1,NSTRNG          SS8L566
   TT(II,JJ) = TT(II,JJ) + ( AL(1,1,3,I,3,M) * ( AA * AS(L)          SS8L567
1          * ESW(J,L) * ESW(N,L) + AB1 * YBARS(L) * AS(L) * (          SS8L568
2          ESW(J,L) * ESDW(N,L) + ESDW(J,L) * ESW(N,L) ) + AB2 * (          SS8L569
3          XIZZS(L) + XIYYS(L) ) * ESDW(J,L) * ESDW(N,L) ) + A1 *          SS8L570
4          XIYYS(L) * AL(1,2,3,I,3,M) * ESW(J,L) * ESW(N,L) ) * RHOS(L)          SS8L571
460 CONTINUE          SS8L572
   IF ( NRING .EQ. 0 ) GO TO 470          SS8L573
   DO 470 K=1,NRING          SS8L574
   TT(II,JJ) = TT(II,JJ) + RHOR(K) * ( AL(2,1,3,J,3,N) * ( BB * AR(K)          SS8L575
1          * ERW(I,K) * ERW(M,K) + XBARR(K) * A1B * AR(K) * (          SS8L576
2          ERW(I,K) * ERDW(M,K) + ERDW(I,K) * ERW(M,K) )          SS8L577
2          + A2B * ( XIXXR(K) + XIZZR(K) ) *          SS8L578
3          ERDW(I,K) * ERDW(M,K) ) + B1 * AL(2,2,3,J,3,N) * XIXXR(K)          SS8L579
4          * ERW(I,K) * ERW(M,K) )          SS8L580
470 CONTINUE          SS8L581
   IF ( NLMASS .EQ. 0 ) GO TO 480          SS8L582
   DO 480 L=1,NLMASS          SS8L583
   TT(II,JJ) = TT(II,JJ) + PMASS(L) * EVAL(1,1,3,I,IPWW(L)) *          SS8L584
1EVAL(1,2,3,J,IPWY(L)) * EVAL(1,1,3,M,IPWW(L)) * EVAL(1,2,3,N,IPWY(L))          SS8L585
480 CONTINUE          SS8L586
   IF ( IEDGE .EQ. 0 ) GO TO 510          SS8L587
   X(45) = 0.          SS8L588
   DO 490 L=1,NPNX          SS8L589
   DO 490 K=1,NPNY          SS8L590
   X(45) = X(45) - PX(L,K) * $W(L,1,2,I,M) * $W(K,2,1,J,N) * A1B          SS8L591
1          - PY(L,K) * $W(L,1,1,I,M) * $W(K,2,2,J,N) * AB1          SS8L592
2          - PXY(L,K) * ($W(L,1,3,I,M) * $W(K,2,3,N,J)          SS8L593
3          + $W(L,1,3,M,I) * $W(K,2,3,J,N) )          SS8L594
490 CONTINUE          SS8L595
   U(KK,LL) = X(45)          SS8L596
   IF ( NSTRNG .EQ. 0 ) GO TO 500          SS8L597
   DO 500 L=1,NSTRNG          SS8L598
   U(KK,LL) = U(KK,LL) - PAXS(L) * AL(1,2,3,I,3,M) * A1          SS8L599
1          * ESW(J,L) * ESW(N,L)          SS8L600
500 CONTINUE          SS8L601
   IF ( NRING .EQ. 0 ) GO TO 510          SS8L602
   DO 510 K=1,NRING          SS8L603
   U(KK,LL) = U(KK,LL) - PAXR(K) * B1 * AL(2,2,3,J,3,N)          SS8L604
1          * ERW(I,K) * ERW(M,K)          SS8L605
510 CONTINUE          SS8L606
   IF ( IFLAGW .EQ. 0 ) GO TO 1000          SS8L607
   IF ( JJ .GT. NTUX*NTUY + NTVX*NTVY + 1 ) GO TO 1000          SS8L608
   IF ( IFLAGW .EQ. 2 ) GO TO 521          SS8L609
   X(46) = 0.          SS8L610
   DO 520 K=1,NQTX          SS8L611
   DO 520 L=1,NQTY          SS8L612
520 X(46) = X(46) + QQ(K,L) * AB * P(K,1,1,3,I) * P(L,2,1,3,J)          SS8L613
   Q(II) = X(46)          SS8L614
521 CONTINUE          SS8L615

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| IF (IEDGE .EQ. 0) GO TO 525 | SS8L616 |
| IF (NSTRNG .EQ. 0) GO TO 522 | SS8L617 |
| DO 522 L=1,NSTRNG | SS8L618 |
| S(II) = S(II) + PAXS(L) * A1 * ZBARS(L) * P(1,1,3,3,I) * ESW(J,L) | SS8L619 |
| 522 CONTINUE | SS8L620 |
| IF (NRING .EQ. 0) GO TO 523 | SS8L621 |
| DO 523 K=1,NRING | SS8L622 |
| S(II) = S(II) - PAXR(K) * (- ZBARR(K) * P(1,2,3,3,J) | SS8L623 |
| 1 * ERW(I,K) + P(1,2,1,3,J) * (BR1 | SS8L624 |
| 2 * ERW(I,K) + BR1 * XBARR(K) * ERDW(I,K))) | SS8L625 |
| 523 CONTINUE | SS8L626 |
| DO 524 K=1,NPNX | SS8L627 |
| DO 524 L=1,NPNY | SS8L628 |
| 524 S(II) = S(II) - ABR1 * PY(K,L) * P(K,1,1,3,I) * P(L,2,1,3,J) | SS8L629 |
| 525 IF (NPTLDS .EQ. 0) GO TO 530 | SS8L630 |
| DO 530 L=1,NPTLDS | SS8L631 |
| Q(II) = Q(II) + PC(L) * EVAL(1,1,3,I,IPXX(L)) | SS8L632 |
| 1 * EVAL(1,2,3,J,IPYY(L)) | SS8L633 |
| 530 CONTINUE | SS8L634 |
| IF (NPTMOM .EQ. 0) GO TO 550 | SS8L635 |
| DO 550 L=1,NPTMOM | SS8L636 |
| IF (ITAGCM(L) .EQ. 1) GO TO 540 | SS8L637 |
| C TAG = 1 FOR MY , = 2 FOR MX | SS8L638 |
| Q(II) = Q(II) - A1 * FC(L) | SS8L639 |
| 1 * EVAL(2,1,3,I,IFXX(L)) * EVAL(1,2,3,J,IFYY(L)) | SS8L640 |
| GO TO 550 | SS8L641 |
| 540 Q(II) = Q(II) - B1 * FC(L) | SS8L642 |
| 1 * EVAL(1,1,3,I,IFXX(L)) * EVAL(2,2,3,J,IFYY(L)) | SS8L643 |
| 550 CONTINUE | SS8L644 |
| IF (NLNMOM .EQ. 0) GO TO 1000 | SS8L645 |
| DO 570 L=1,NLNMOM | SS8L646 |
| IF (ITAGLM(L) .EQ. 1) GO TO 560 | SS8L647 |
| Q(II) = Q(II) - A1B * PLMOM(L) * P(1,2,1,3,J) | SS8L648 |
| 1 * EVAL(2,1,3,I,IDISLM(L)) | SS8L649 |
| GO TO 570 | SS8L650 |
| 560 Q(II) = Q(II) - AB1 * PLMOM(L) * P(1,1,1,3,I) | SS8L651 |
| 1 * EVAL(2,2,3,J,IDISLM(L)) | SS8L652 |
| 570 CONTINUE | SS8L653 |
| GO TO 1000 | SS8L654 |
| 580 V(II,JJ) = V(JJ,II) | SS8L655 |
| IF (IFLAGD .EQ. 0) GO TO 1000 | SS8L656 |
| TT(II,JJ) = TT(JJ,II) | SS8L657 |
| 1000 CONTINUE | SS8L658 |
| CALL STATUS (ITIME) | SS8L659 |
| TIME(6) = .01*ITIME(8) | SS8L660 |
| ET = TIME(6) - TIME(5) | SS8L661 |
| C ** CHANGE SIGN ON Q | SS8L662 |
| DO 1584 I=1,MATSIJ | SS8L663 |
| 1584 Q(I) = -Q(I) | SS8L664 |
| DO 2584 I=1,MWSIJ | SS8L665 |
| DO 2584 J=1,MWSIJ | SS8L666 |
| 2584 U(I,J) = -U(I,J) | SS8L667 |
| DO 585 I=1,MATSIJ | SS8L668 |
| QHOLD(I) = Q(I) | SS8L669 |
| SHOLD(I) = S(I) | SS8L670 |
| DO 585 J=1,MATSIJ | SS8L671 |

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| 585 | VHOLD(I,J) = V(I,J) | SS8L672 |
| C | | SS8L673 |
| | IF (INTprt .NE. 1) GO TO 670 | SS8L674 |
| | WRITE (6,590) ET | SS8L675 |
| 590 | FORMAT ('OTIME REQUIRED TO ASSEMBLE MATRICES = ',F7.3,' SEC.') | SS8L676 |
| | WRITE (6,610) NAMEV | SS8L677 |
| 610 | FORMAT ('MATRIX ',A4) | SS8L678 |
| | DO 630 I=1,MATSIZ | SS8L679 |
| | WRITE (6,620) | SS8L680 |
| 620 | FORMAT ('O') | SS8L681 |
| 630 | WRITE (6,640) (V(I,J), J=1,MATSIZ) | SS8L682 |
| 640 | FORMAT (' ',10E12.4) | SS8L683 |
| | IF (IFLAGD .EQ. 0) GO TO 651 | SS8L684 |
| | WRITE (6,610) NAMETT | SS8L685 |
| | DO 650 I=1,MATSIZ | SS8L686 |
| | WRITE (6,620) | SS8L687 |
| 650 | WRITE (6,640) (TT(I,J), J=1,MATSIZ) | SS8L688 |
| 651 | CONTINUE | SS8L689 |
| | IF (IEDGE .EQ. 0) GO TO 661 | SS8L690 |
| | WRITE (6,610) NAMEU | SS8L691 |
| | DO 660 I=1,MWSIZ | SS8L692 |
| | WRITE (6,620) | SS8L693 |
| 660 | WRITE (6,640) (U(I,J), J=1,MWSIZ) | SS8L694 |
| 661 | CONTINUE | SS8L695 |
| | IF (IFLAGW .EQ. 0) GO TO 670 | SS8L696 |
| | WRITE (6,610) NAMES | SS8L697 |
| | WRITE (6,640) (S(J), J=1,MATSIZ) | SS8L698 |
| | WRITE (6,610) NAMEQ | SS8L699 |
| | WRITE (6,640) (Q(J), J=1,MATSIZ) | SS8L700 |
| 670 | CONTINUE | SS8L701 |
| | RETURN | SS8L702 |
| | END | SS8L703 |

CC = 00704

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|---|--|---------|
| | SUBROUTINE SOLVE | SS8M000 |
| C | | SS8M001 |
| | DIMENSION V(150,150), T(150,150), Z(150,150) | SS8M002 |
| | DIMENSION VV(22500), TV(22500), ZV(22500) | SS8M003 |
| | DIMENSION Z1(100,100), Z2(100,50), Z3(50,100), Z4(50,50) | SS8M004 |
| | DIMENSION U(50,50), Q(150) | SS8M005 |
| | DIMENSION WORK1(150), WORK2(150) | SS8M006 |
| | DIMENSION S(150) | SS8M007 |
| | DIMENSION ITIME(12), TIME(50) | SS8M008 |
| | DIMENSION INDEX(150) | SS8M009 |
| C | | SS8M010 |
| | COMMON U | SS8M011 |
| | COMMON / BLOCK / T | SS8M012 |
| | COMMON / ARRAYS / V | SS8M013 |
| | COMMON / CNTROL / IFLAGD, IFLAGB, IFLAGW, IBCX, IBCY, I\$, IEDGE, | SS8M014 |
| | 1 JS(2), KEY, KS(2), INTprt, IKDF, IFLEX | SS8M015 |
| | COMMON / NUMBER / ND2(6), NTWY, NMODES, ND3(12), NUVW, NUV, NW | SS8M016 |
| | COMMON / NUMBER / ITX, ITY | SS8M017 |
| | COMMON / ZWORK / Z | SS8M018 |
| | COMMON / PARAM / Q, S, WORK1, WORK2 | SS8M019 |
| | COMMON / \$TIME / TIME, ITIME | SS8M020 |
| | COMMON / MODES / MM(50), NN(50) | SS8M021 |
| C | | SS8M022 |
| | EQUIVALENCE (Z1(1), Z(1)), (Z2(1), Z(10001)) | SS8M023 |
| | EQUIVALENCE (Z3(1), Z(15001)), (Z4(1), Z(20001)) | SS8M024 |
| | EQUIVALENCE (V(1), VV(1)), (T(1), TV(1)), (Z(1), ZV(1)) | SS8M025 |
| C | | SS8M026 |
| | CALL STATUS (ITIME) | SS8M027 |
| | TIME(10) = .01*ITIME(8) - TIME(1) | SS8M028 |
| | IF (INTprt .EQ. 1) WRITE (6,10) TIME(10) | SS8M029 |
| | 10 FORMAT ('0ELAPSED TIME AT BEGINNING OF ',7H'SOLVE', ' = ',F7.2) | SS8M030 |
| C | | SS8M031 |
| | IF (IFLAGW .NE. 0) GO TO 20 | SS8M032 |
| | IF (IFLAGD .NE. 0) GO TO 90 | SS8M033 |
| | IF (IFLAGB .NE. 0) GO TO 170 | SS8M034 |
| C | | SS8M035 |
| C | ** STATIC DEFLECTION | SS8M036 |
| C | | SS8M037 |
| | 20 CONTINUE | SS8M038 |
| | IF (IEDGE .EQ. 1) GO TO 40 | SS8M039 |
| | DO 30 I=1,NUVW | SS8M040 |
| | DO 30 J=1,NUVW | SS8M041 |
| | 30 T(I,J) = V(I,J) | SS8M042 |
| | GO TO 65 | SS8M043 |
| | 40 DO 60 I=1,NUVW | SS8M044 |
| | DO 60 J=1,NUVW | SS8M045 |
| | IF (I.GT.NUV .AND. J.GT.NUV) GO TO 50 | SS8M046 |
| | T(I,J) = V(I,J) | SS8M047 |
| | GO TO 60 | SS8M048 |
| | 50 K = I-NUV | SS8M049 |
| | L = J-NUV | SS8M050 |
| | T(I,J) = V(I,J) + U(K,L) | SS8M051 |
| | 60 CONTINUE | SS8M052 |
| | 65 CONTINUE | SS8M053 |
| C | | SS8M054 |
| | IF (IFLEX.EQ. 0) GO TO 70 | SS8M055 |

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| CALL REDUCE (1,V,Z1,Z2,Z3,Z4,WORK1,WORK2,NUV,NW) | SS8M056 |
| CALL FLEX | SS8M057 |
| 70 CONTINUE | SS8M058 |
| C DO 80 I=1,NUVW | SS8M059 |
| 80 WORK1(I) = -S(I) - Q(I) | SS8M060 |
| C CALL SWITCH (T, NUVW, 150, 0., 1.) | SS8M061 |
| CALL SIMEQ (T,WORK1,NUVW,1,150,150,0.,IER) | SS8M062 |
| KEY = 1 | SS8M063 |
| GO TO 1000 | SS8M064 |
| C ** VIBRATION | SS8M065 |
| C 90 CONTINUE | SS8M066 |
| CALL STATUS (ITIME) | SS8M067 |
| TIME(11) = .01*ITIME(8) - TIME(1) | SS8M068 |
| DO 100 I=1,NUVW | SS8M069 |
| DO 100 J=1,NUVW | SS8M070 |
| 100 Z(I,J) = V(I,J) | SS8M071 |
| CALL SWITCH (T, NUVW, 150, 0., 1.) | SS8M072 |
| C CALL ARRAY (2,NUVW,NUVW,150,150,VV,V) | SS8M073 |
| CALL ARRAY (2,NUVW,NUVW,150,150,ZV,Z) | SS8M074 |
| CALL ARRAY (2,NUVW,NUVW,150,150,TV,T) | SS8M075 |
| CALL NROOT (NUVW,ZV,TV,WORK1,VV) | SS8M076 |
| CALL ARRAY (1,NUVW,NUVW,150,150,VV,V) | SS8M077 |
| DO 120 J=1,NUVW | SS8M078 |
| WORK2(J) = 1.E+40 | SS8M079 |
| DO 110 I=1,NUVW | SS8M080 |
| IF (WORK1(I).GE.WORK2(J)) GO TO 110 | SS8M081 |
| WORK2(J) = WORK1(I) | SS8M082 |
| INDEX(J) = I | SS8M083 |
| 110 CONTINUE | SS8M084 |
| 120 WORK1(INDEX(J)) = 1.E+40 | SS8M085 |
| DO 130 J=1,NUVW | SS8M086 |
| WORK1(J) = WORK2(J) | SS8M087 |
| DO 130 K=1,NUVW | SS8M088 |
| 130 T(J,K) = V(K,INDEX(J)) | SS8M089 |
| CALL STATUS (ITIME) | SS8M090 |
| TIME(12) = .01*ITIME(8) - TIME(1) | SS8M091 |
| ET = TIME(12) - TIME(11) | SS8M092 |
| IF (INTPT .EQ. 1) WRITE (6,140) ET | SS8M093 |
| 140 FORMAT ('OTIME TO SOLVE FOR EIGENVALUES AND EIGENVECTORS = ',F7.2) | SS8M094 |
| DO 55 I=1,NUVW | SS8M095 |
| BIG = ABS(T(I,NUV+1)) | SS8M096 |
| NSAVE = 1 | SS8M097 |
| DO 59 J=2,NW | SS8M098 |
| IF (ABS (T(I,J+NUV)).LE.BIG) GO TO 59 | SS8M099 |
| BIG = ABS (T(I,J+NUV)) | SS8M100 |
| NSAVE = J | SS8M101 |
| 59 CONTINUE | SS8M102 |
| M = ITX | SS8M103 |
| N = ITY | SS8M104 |
| IF (NSAVE .EQ. 1) GO TO 3 | SS8M105 |
| DO 2 J=2,NSAVE | SS8M106 |
| | SS8M107 |
| | SS8M108 |
| | SS8M109 |
| | SS8M110 |
| | SS8M111 |

| | |
|---|---------|
| IF (N+1-ITY .GE. NTWY) GO TO 1 | SS8M112 |
| N = N+1 | SS8M113 |
| GO TO 2 | SS8M114 |
| 1 N = ITY | SS8M115 |
| M = M+1 | SS8M116 |
| 2 CONTINUE | SS8M117 |
| 3 CONTINUE | SS8M118 |
| MM(I) = M | SS8M119 |
| NN(I) = N | SS8M120 |
| IF (WORK1(I) .GT. 0.) WORK1(I)=SQRT(WORK1(I))/6.2831853 | SS8M121 |
| 55 CONTINUE | SS8M122 |
| WRITE (6,160) (WORK1(I), MM(I), NN(I) , I=1,NUVW) | SS8M123 |
| 160 FORMAT ('1 FREQUENCY',7X,'M',5X,'N'/'0',E13.5,4X,I2,4X,I2)) | SS8M124 |
| KEY = 2 | SS8M125 |
| GO TO 1000 | SS8M126 |
| C | SS8M127 |
| C ** BUCKLING | SS8M128 |
| C | SS8M129 |
| 170 CONTINUE | SS8M130 |
| DO 180 I=1,NW | SS8M131 |
| DO 180 J=1,NW | SS8M132 |
| 180 U(I,J) = - U(I,J) | SS8M133 |
| C | SS8M134 |
| IF (IFLEX .EQ. 0) GO TO 190 | SS8M135 |
| CALL REDUCE (1,V,Z1,Z2,Z3,Z4,WORK1,WORK2,NUV,NW) | SS8M136 |
| CALL FLEX | SS8M137 |
| 190 CONTINUE | SS8M138 |
| IF (IKDF .NE. 0) CALL KDF (BUCKNX) | SS8M139 |
| C | SS8M140 |
| IF (IFLEX .EQ. 0) GO TO 200 | SS8M141 |
| CALL YOSFEM (2,Z,NW,NW,150,U,NW,50,V,WORK1) | SS8M142 |
| GO TO 210 | SS8M143 |
| 200 CALL REDUCE (2,V,Z1,Z2,Z3,Z4,WORK1,WORK2,NUV,NW) | SS8M144 |
| CALL YOSFEM (2,V,NW,NW,150,U,NW,50,Z,WORK1) | SS8M145 |
| 210 CONTINUE | SS8M146 |
| IF (IFLAGB .EQ. 1) CALL EIGONE (U,WORK1,NW,50) | SS8M147 |
| IF (IFLAGB .EQ. 2) CALL EIGALL (U,WORK1,NW,50,1,2) | SS8M148 |
| KEY = 3 | SS8M149 |
| 1000 CONTINUE | SS8M150 |
| RETURN | SS8M151 |
| END | SS8M152 |
| SUBROUTINE SWITCH (DIAG, N, NMAX, FROM, TO) | SS8M153 |
| C CHANGES A DIAGONAL TERM FROM 0 TO 1 OR FROM 1 TO 0 . | SS8M154 |
| DIMENSION DIAG(NMAX,N) | SS8M155 |
| DO 10 I=1,N | SS8M156 |
| IF (DIAG(I,I) .EQ. FROM) DIAG(I,I) = TO | SS8M157 |
| 10 CONTINUE | SS8M158 |
| RETURN | SS8M159 |
| END | SS8M160 |

CC = 00161

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|-----|--|---------|
| C | SUBROUTINE YOSFEM (NOPT, A,NRA,NCA,MRA,B,NCB,MRB,C,WORK) | SS8N000 |
| C | ** YOSFEM = YE OLDE SUBROUTINE FOR EFFICIENT MULTIPLICATION. | SS8N001 |
| C | ** NOPT = 1, 2, OR 3 | SS8N002 |
| C | ** = 1 , COMPUTES A = A * B | SS8N003 |
| C | ** = 2 , COMPUTES B = A * B | SS8N004 |
| C | ** = 3 , COMPUTES C = A * B | SS8N005 |
| C | ** A = AN NRA BY NCA MATRIX | SS8N006 |
| C | ** NRA = NUMBER OF ROWS IN A | SS8N007 |
| C | ** NCA = NUMBER OF COLUMNS IN A | SS8N008 |
| C | ** MRA = MAXIMUM NUMBER OF ROWS IN A | SS8N009 |
| C | ** B = AN NCA BY NCB MATRIX | SS8N010 |
| C | ** NCB = NUMBER OF COLUMNS IN B | SS8N011 |
| C | ** MRB = MAXIMUM NUMBER OF ROWS IN B | SS8N012 |
| C | ** C = AN NRA BY NCB MATRIX | SS8N013 |
| C | ** WORK = A WORK VECTOR OF LENGTH NRA | SS8N014 |
| C | | SS8N015 |
| C | DIMENSION A(MRA,NCA), B(MRB,NCB), C(MRA,NCB), WORK(NRA) | SS8N016 |
| C | | SS8N017 |
| | IF (NOPT .NE. 1) GO TO 40 | SS8N018 |
| | DO 30 I=1,NRA | SS8N019 |
| | DO 20 M=1,NCA | SS8N020 |
| 20 | WORK(M) = A(I,M) | SS8N021 |
| | DO 30 J=1,NCB | SS8N022 |
| | A(I,J) = 0. | SS8N023 |
| | DO 30 K=1,NCA | SS8N024 |
| 30 | A(I,J) = A(I,J) + WORK(K) * B(K,J) | SS8N025 |
| | GO TO 100 | SS8N026 |
| 40 | IF (NOPT .NE. 2) GO TO 70 | SS8N027 |
| | DO 60 J=1,NCB | SS8N028 |
| | DO 50 M=1,NCA | SS8N029 |
| 50 | WORK(M) = B(M,J) | SS8N030 |
| | DO 60 I=1,NRA | SS8N031 |
| | B(I,J) = 0. | SS8N032 |
| | DO 60 K=1,NCA | SS8N033 |
| 60 | B(I,J) = B(I,J) + A(I,K) * WORK(K) | SS8N034 |
| | GO TO 100 | SS8N035 |
| 70 | DO 80 I=1,NRA | SS8N036 |
| | DO 80 J=1,NCB | SS8N037 |
| | C(I,J) = 0. | SS8N038 |
| | DO 80 K=1,NCA | SS8N039 |
| 80 | C(I,J) = C(I,J) + A(I,K) * B(K,J) | SS8N040 |
| 100 | RETURN | SS8N041 |
| | END | SS8N042 |
| | | SS8N043 |

CC = 00044

| | | |
|---|--|---------|
| | SUBROUTINE EIGONE (A, X, N, NRA) | SS8N045 |
| C | | SS8N046 |
| C | THIS SUBROUTINE COMPUTES THE INVERSE OF THE LARGEST EIGEN VALUE | SS8N047 |
| C | OF AN N BY N MATRIX, AND THE CORRESPONDING MODE SHAPE, BY SIMPLE | SS8N048 |
| C | ITERATION. | SS8N049 |
| C | CAST PROBLEM IN THE FORM $A \cdot X = X / OLAMB$ | SS8N050 |
| C | | SS8N051 |
| | DIMENSION A(NRA,N), X(N) | SS8N052 |
| | DIMENSION B(150,150), ITIME(12), TIME(50) | SS8N053 |
| | DIMENSION USED(150), XA(150), XX(150) | SS8N054 |
| | DIMENSION XXX(150), XY(150), MPN(150) | SS8N055 |
| C | | SS8N056 |
| | COMMON / ZWORK / B | SS8N057 |
| | COMMON / PARAM / XA, XX, USED, XXX, XY, MPN | SS8N058 |
| | COMMON / \$TIME / TIME, ITIME | SS8N059 |
| | COMMON / CNTROL / IS(12), INTPT | SS8N060 |
| C | | SS8N061 |
| | CALL STATUS (ITIME) | SS8N062 |
| | TIME(20) = .01*ITIME(8) - TIME(1) | SS8N063 |
| | PDIDLE=.00001 | SS8N064 |
| | MAD= 72 | SS8N065 |
| | IKEP=1 | SS8N066 |
| | OLAMB = 0. | SS8N067 |
| | DO 1 I=1,N | SS8N068 |
| | 1 X(I)=.1 | SS8N069 |
| | M=1 | SS8N070 |
| | 6 XMIN=0 | SS8N071 |
| | OLAMBO=OLAMB | SS8N072 |
| C | A NEW MODE SHAPE IS COMPUTED AS A TIMES X, AND THE LARGEST ELEMENT | SS8N073 |
| C | OF THE NEW X IS STORED IN XMIN. | SS8N074 |
| | DO 44 I=1,N | SS8N075 |
| | 44 XA(I)=X(I) | SS8N076 |
| | DO 42 K=1,6 | SS8N077 |
| | DO 3 I=1,N | SS8N078 |
| | XX(I)=0. | SS8N079 |
| | DO 3 J=1,N | SS8N080 |
| | 3 XX(I)=XX(I)+ A(I,J)*X(J) | SS8N081 |
| | XPQ=X(N)/XX(N) | SS8N082 |
| | XPR=XPQ/ABS(XPQ) | SS8N083 |
| | DO 41 I=1,N | SS8N084 |
| | XXX(I)=X(I) | SS8N085 |
| | 41 X(I)=XX(I) | SS8N086 |
| | 42 CONTINUE | SS8N087 |
| | DO 2 I=1,N | SS8N088 |
| | IF(ABS(XMIN)-ABS(XX(I)))7,2,2 | SS8N089 |
| | 7 XMIN = XX(I) | SS8N090 |
| | JJ= I | SS8N091 |
| | MPN(IKEP)=I | SS8N092 |
| | 2 CONTINUE | SS8N093 |
| C | THE NEW VECTOR IS NORMALIZED WITH RESPECT TO XMIN. | SS8N094 |
| | DO 4 I=1,N | SS8N095 |
| | 4 XX(I)= XX(I)/ XMIN | SS8N096 |
| C | THE LATEST APPROXIMATION TO 1 DIVIDED BY THE LARGEST EIGEN VALUE | SS8N097 |
| C | IS COMPUTED. | SS8N098 |
| | OLAMB=XA(JJ)/XMIN | SS8N099 |
| | OLAMB= ((ABS(OLAMB))**.1666667)*XPR | SS8N100 |

| | | |
|-----|--|---------|
| C | THE NEW VECTOR IS STORED FOR A NEW ITERATION. | SS8N101 |
| | DO 9 I =1,N | SS8N102 |
| 9 | X(I) = XX(I) | SS8N103 |
| C | THE RELATIVE CHANGE IN OLAMB IS THE BASIS FOR CONVERGENCE. | SS8N104 |
| | IF(ABS((OLAMB - OLAMBO) /OLAMB) .LT.PDIDLE)GO TO 5 | SS8N105 |
| | M=M+1 | SS8N106 |
| | IF(M.GT.15)PDIDLE =.0005 | SS8N107 |
| | IF (M.LT.50) GO TO 6 | SS8N108 |
| | WRITE(6,8)OLAMBO,OLAMB | SS8N109 |
| 8 | FORMAT('ONO CONVERGENCE'2E15.7) | SS8N110 |
| | XY(IKEP)=OLAMB | SS8N111 |
| | DO 60 IJ=1,N | SS8N112 |
| 60 | B(IKEP,IJ) =X(IJ) | SS8N113 |
| | GO TO 39 | SS8N114 |
| 5 | IF(M.GT.15)GO TO 20 | SS8N115 |
| | M=M+1 | SS8N116 |
| | GO TO 6 | SS8N117 |
| 20 | IF (INTPT .EQ. 1) WRITE (6,12) M | SS8N118 |
| 12 | FORMAT('0'14,' ITERATIONS') | SS8N119 |
| | DO 43 I=1,N | SS8N120 |
| 43 | X(I)=(X(I)+XXX(I)/OLAMB/XMIN)/2. | SS8N121 |
| | DO 55 I=1,N | SS8N122 |
| 55 | B(IKEP,I)=X(I) | SS8N123 |
| | XY(IKEP)=OLAMB | SS8N124 |
| 39 | CONTINUE | SS8N125 |
| 500 | DO 38 J=1,IKEP | SS8N126 |
| | X(J)=XY(J) | SS8N127 |
| | DO 38 I=1,N | SS8N128 |
| 38 | A(J,I)=B(J,I) | SS8N129 |
| 40 | CONTINUE | SS8N130 |
| | CALL STATUS (ITIME) | SS8N131 |
| | TIME(21) = .01*ITIME(8) - TIME(1) | SS8N132 |
| | ET = TIME(21) - TIME(20) | SS8N133 |
| | IF (INTPT .EQ. 1) WRITE (6,600) ET | SS8N134 |
| 600 | FORMAT ('OTIME REQUIRED TO FIND ONE EIGENVALUE AND EIGENVECTOR = ' | SS8N135 |
| 1 | ,F7.2) | SS8N136 |
| | RETURN | SS8N137 |
| | END | SS8N138 |

CC = 00094

| | | |
|------|---|---------|
| | SUBROUTINE EIGALL (A, X, N, NRA, ITAG, MODES) | SS8P000 |
| C | | SS8P001 |
| C ** | THIS SUBROUTINE FINDS ALL THE EIGENVALUES OF THE NRA BY N | SS8P002 |
| C ** | MATRIX A. IT ALSO FINDS THE EIGENVECTORS CORRESPONDING TO | SS8P003 |
| C ** | THE FIRST 'MODES' EIGENVALUES. | SS8P004 |
| C ** | THE MATRIX EQUATION IS IN THE FORM $A*X = X/EGNVAL$ | SS8P005 |
| C | | SS8P006 |
| | DIMENSION A(NRA,N), X(N) | SS8P007 |
| | DIMENSION USED(150), XX(150), WORK(3000) | SS8P008 |
| | DIMENSION Z(150,150), XY(150), NDUM1(150), NDUM2(150) | SS8P009 |
| | DIMENSION VEC(150), ITIME(12), TIME(50) | SS8P010 |
| C | | SS8P011 |
| | COMMON / ZWORK / Z | SS8P012 |
| | COMMON / PARAM / XX, XY, USED, VEC, NDUM1, NDUM2 | SS8P013 |
| | COMMON / EIGWRK / WORK | SS8P014 |
| | COMMON / CNTROL / IFLAGD, I\$(11), INTPRT | SS8P015 |
| | COMMON / COMMON / DUMCOM(150) | SS8P016 |
| | COMMON / \$TIME / TIME, ITIME | SS8P017 |
| C | | SS8P018 |
| | DO 10 J=1,N | SS8P019 |
| 10 | X(J) = 0. | SS8P020 |
| | DO 20 I=1,N | SS8P021 |
| | DO 20 J=1,N | SS8P022 |
| 20 | Z(I,J) = A(I,J) | SS8P023 |
| | IPRNT = INTPRT | SS8P024 |
| | CALL STATUS (ITIME) | SS8P025 |
| | TIME(17) = .01*ITIME(8) - TIME(1) | SS8P026 |
| | CALL HESSEN (Z, N, 150) | SS8P027 |
| | CALL QREIG (Z, N, XY, XX, IPRNT, 150) | SS8P028 |
| | CALL STATUS (ITIME) | SS8P029 |
| | TIME(18) = .01*ITIME(8) - TIME(1) | SS8P030 |
| | ET = TIME(18) - TIME(17) | SS8P031 |
| | IF (INTPRT .EQ. 1) WRITE (6,21) ET | SS8P032 |
| 21 | FORMAT ('OTIME REQUIRED TO FIND ALL EIGENVALUES = ',F7.2) | SS8P033 |
| | IF (ITAG .EQ. 3) GO TO 70 | SS8P034 |
| | GREAT= 0. | SS8P035 |
| | DO 71 I=1,N | SS8P036 |
| | IF(XX(I).NE.0.)GO TO 71 | SS8P037 |
| | IF (XY(I) .EQ. 0.) GO TO 71 | SS8P038 |
| | IF(ABS(GREAT).GT.ABS(XY(I)))GO TO 71 | SS8P039 |
| | GREAT = XY(I) | SS8P040 |
| 71 | CONTINUE | SS8P041 |
| | GREAT2 = -0. | SS8P042 |
| | DO 72 I=1,N | SS8P043 |
| | IF(XX(I).NE.0.)GO TO 72 | SS8P044 |
| | IF (XY(I) .EQ. 0.) GO TO 72 | SS8P045 |
| | IF(GREAT*XY(I).GT.0..OR.ABS(GREAT2).GT.ABS(XY(I))) GO TO 72 | SS8P046 |
| | GREAT2 = XY(I) | SS8P047 |
| 72 | CONTINUE | SS8P048 |
| | MODES = 2 | SS8P049 |
| | XY(1)= GREAT | SS8P050 |
| | XY(2)= GREAT2 | SS8P051 |
| | X(1)= 1./GREAT | SS8P052 |
| | IF(ABS(GREAT2).LT.1.E-40)GO TO 80 | SS8P053 |
| | X(2)= 1./GREAT2 | SS8P054 |
| | GO TO 73 | SS8P055 |

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|---|---------|
| 80 X(2)=0. | SS8P056 |
| MODES = 1 | SS8P057 |
| GO TO 73 | SS8P058 |
| 70 CONTINUE | SS8P059 |
| DO 50 J=1,N | SS8P060 |
| IF (XY(J) .NE. 0.) XY(J) = 1./XY(J) | SS8P061 |
| 50 CONTINUE | SS8P062 |
| DO 74 J=1,N | SS8P063 |
| IF(XX(J).NE.0.)XY(J)= 0. | SS8P064 |
| DO 75 I=J,N | SS8P065 |
| IF(XX(I).NE.0.)GO TO 75 | SS8P066 |
| IF (XY(I) .EQ. 0.) GO TO 75 | SS8P067 |
| IF(XY(I).LT.XY(J))GO TO 75 | SS8P068 |
| GREAT= XY(J) | SS8P069 |
| XY(J)= XY(I) | SS8P070 |
| XY(I)= GREAT | SS8P071 |
| GREAT= XX(J) | SS8P072 |
| XX(J)= XX(I) | SS8P073 |
| XX(I)= GREAT | SS8P074 |
| 75 CONTINUE | SS8P075 |
| IF (XY(J) .NE. 0.) X(J) = 1./XY(J) | SS8P076 |
| 74 CONTINUE | SS8P077 |
| 73 CONTINUE | SS8P078 |
| DO 77 I=1,MODES | SS8P079 |
| DO 78 J=1,N | SS8P080 |
| DO 78 K=1,N | SS8P081 |
| 78 Z(J,K) = A(J,K) | SS8P082 |
| EGNVAL = X(I) | SS8P083 |
| IF (ITAG .NE. 3) EGNVAL = 1./X(I) | SS8P084 |
| CALL EGNVCT (Z, XX, EGNVAL, VEC, NDUM1, NDUM2, N, 150, IPRNT) | SS8P085 |
| JO = (I-1)*N | SS8P086 |
| DO 79 J=1,N | SS8P087 |
| K = JO + J | SS8P088 |
| 79 WORK(K) = VEC(J) | SS8P089 |
| 77 CONTINUE | SS8P090 |
| DO 90 I=1,MODES | SS8P091 |
| J = (I-1)*N | SS8P092 |
| DO 90 K=1,N | SS8P093 |
| L = J + K | SS8P094 |
| 90 A(I,K) = WORK(L) | SS8P095 |
| CALL STATUS (ITIME) | SS8P096 |
| TIME(19) = .01*ITIME(8) - TIME(1) | SS8P097 |
| ET = TIME(19) - TIME(18) | SS8P098 |
| IF (INTPT .EQ. 1) WRITE (6,91) ET | SS8P099 |
| 91 FORMAT ('OTIME REQUIRED TO FIND EIGENVECTORS = ',F7.2) | SS8P100 |
| RETURN | SS8P101 |
| END | SS8P102 |

CC = 00103

| | | |
|----|--|---------|
| | SUBROUTINE EGNVCT (C1, C2, EIGEN, C3, N1, N2, N, NROWS, NTIME) | SS8Q000 |
| C | | SS8Q001 |
| C | SUBROUTINE TO OBTAIN EIGENVECTOR FROM REAL NON-SYMMETRIC | SS8Q002 |
| C | MATRICES FOR WHICH THE EIGENVALUE IS KNOWN. THE METHOD | SS8Q003 |
| C | USED IS THE DIRECT METHOD OUTLINED IN ERR-FW- BY DR. | SS8Q004 |
| C | A. M. CUNNINGHAM. ALL ARITHMETIC IS IN DOUBLE PRECISION. | SS8Q005 |
| C | | SS8Q006 |
| | DIMENSION C1(NROWS,NROWS), C2(NROWS), C3(NROWS), N1(NROWS), | SS8Q007 |
| 1 | N2(NROWS) | SS8Q008 |
| C | | SS8Q009 |
| | II3 = N | SS8Q010 |
| | II2 = N - 1 | SS8Q011 |
| | IF (NTIME .NE. 0) CALL STATUS (N1) | SS8Q012 |
| | IT1 = N1(8) | SS8Q013 |
| | D1 = 0.0 D0 | SS8Q014 |
| | DO 20 J=1,N | SS8Q015 |
| | N1(J) = J | SS8Q016 |
| | N2(J) = J | SS8Q017 |
| | C1(J,J) = C1(J,J) - EIGEN | SS8Q018 |
| | DO 10 I=1,N | SS8Q019 |
| | D2 = ABS(C1(I,J)) | SS8Q020 |
| | IF (D1-D2) 5,10,10 | SS8Q021 |
| 5 | D1 = D2 | SS8Q022 |
| | I1 = I | SS8Q023 |
| | J1 = J | SS8Q024 |
| 10 | CONTINUE | SS8Q025 |
| 20 | CONTINUE | SS8Q026 |
| | DO 150 K6=2,N | SS8Q027 |
| | IF (C1(I1,J1)) 50,30,50 | SS8Q028 |
| 30 | K5 = K6 - 1 | SS8Q029 |
| 35 | WRITE (6,40) K5 | SS8Q030 |
| 40 | FORMAT (1H1, 4X,57H THE REDUCED MATRIX WAS FOUND TO BE SINGULAR ON | SS8Q031 |
| | 1 ITERATION, I4) | SS8Q032 |
| | N1(1) = 1 | SS8Q033 |
| | GO TO 1000 | SS8Q034 |
| C | | SS8Q035 |
| 50 | D1 = 1.0/C1(I1,J1) | SS8Q036 |
| | D2 = C1(I1,II3) | SS8Q037 |
| | D3 = C1(II3,J1) | SS8Q038 |
| | D4 = C1(II3,II3) | SS8Q039 |
| | DO 60 I=1,II2 | SS8Q040 |
| | C3(I) = C1(I,J1) | SS8Q041 |
| | C1(I,J1) = C1(I,II3) | SS8Q042 |
| | C1(I,II3) = -C3(I)*D1 | SS8Q043 |
| | D5 = -C1(I1,I)*D1 | SS8Q044 |
| | C1(I1,I) = C1(II3,I) | SS8Q045 |
| | C1(II3,I) = D5 | SS8Q046 |
| 60 | CONTINUE | SS8Q047 |
| | C3(I1) = D3 | SS8Q048 |
| | C1(I1,J1) = D4 | SS8Q049 |
| | C1(II3,J1) = -D2*D1 | SS8Q050 |
| | C1(I1,II3) = -D3*D1 | SS8Q051 |
| | C1(II3,II3) = D1 | SS8Q052 |
| | IF (II3 .EQ. N) GO TO 80 | SS8Q053 |
| | II4 = II3 + 1 | SS8Q054 |
| | DO 70 I=II4,N | SS8Q055 |

| | |
|---|---------|
| D6 = C1(I1,I) | SS8Q056 |
| C1(I1,I) = C1(II3,I) | SS8Q057 |
| C1(II3,I) = D6 | SS8Q058 |
| C3(I) = C1(I,J1) | SS8Q059 |
| C1(I,J1) = C1(I,II3) | SS8Q060 |
| 70 C1(I,II3) = C3(I) | SS8Q061 |
| 80 I = N1(J1) | SS8Q062 |
| N1(J1) = N1(II3) | SS8Q063 |
| N1(II3) = I | SS8Q064 |
| I = N2(I1) | SS8Q065 |
| N2(I1) = N2(II3) | SS8Q066 |
| N2(II3) = I | SS8Q067 |
| D7 = 0.0 D0 | SS8Q068 |
| DO 140 J=1,II2 | SS8Q069 |
| D8 = C1(II3,J) | SS8Q070 |
| DO 130 I=1,II2 | SS8Q071 |
| C1(I,J) = C1(I,J) + C3(I)*D8 | SS8Q072 |
| D9 = ABS(C1(I,J)) | SS8Q073 |
| IF (D7-D9) 120,130,130 | SS8Q074 |
| 120 D7 = D9 | SS8Q075 |
| I1 = I | SS8Q076 |
| J1 = J | SS8Q077 |
| 130 CONTINUE | SS8Q078 |
| 140 CONTINUE | SS8Q079 |
| II3 = II3 - 1 | SS8Q080 |
| II2 = II2 - 1 | SS8Q081 |
| 150 CONTINUE | SS8Q082 |
| C | SS8Q083 |
| C | SS8Q084 |
| 160 C3(2) = C1(2,1) | SS8Q085 |
| C3(1) = 1.0 | SS8Q086 |
| DO 180 J=3,N | SS8Q087 |
| C3(J) = 0.0 D0 | SS8Q088 |
| J1 = J-1 | SS8Q089 |
| DO 170 I=1,J1 | SS8Q090 |
| C3(J) = C3(J) + C3(I)*C1(J,I) | SS8Q091 |
| 170 CONTINUE | SS8Q092 |
| 180 CONTINUE | SS8Q093 |
| IF (ABS(C1(1,1)) .LT. 1.0 E-20) GO TO 202 | SS8Q094 |
| DO 201 K6=1,2 | SS8Q095 |
| C | SS8Q096 |
| DO 184 J=1,N | SS8Q097 |
| I1 = N2(J) | SS8Q098 |
| DO 182 I=1,N | SS8Q099 |
| IF (I1 .EQ. N1(I)) GO TO 184 | SS8Q100 |
| 182 CONTINUE | SS8Q101 |
| 184 C2(J) = C3(I) | SS8Q102 |
| C | SS8Q103 |
| DO 190 J=2,N | SS8Q104 |
| I1 = N - J + 1 | SS8Q105 |
| J1 = I1 + 1 | SS8Q106 |
| DO 185 I=1,I1 | SS8Q107 |
| C2(I) = C2(I) + C1(I,J1)*C2(J1) | SS8Q108 |
| 185 CONTINUE | SS8Q109 |
| 190 CONTINUE | SS8Q110 |
| D1 = C1(1,1)/C2(1) | SS8Q111 |

| | |
|---|---------|
| C3(1) = 1.0 DO | SS8Q112 |
| DO 200 J=2,N | SS8Q113 |
| I1 = J - 1 | SS8Q114 |
| C3(J) = C2(J)*C1(J,J)*D1 | SS8Q115 |
| DO 195 I=1,I1 | SS8Q116 |
| C3(J) = C3(J) + C1(J,I)*C3(I) | SS8Q117 |
| 195 CONTINUE | SS8Q118 |
| 200 CONTINUE | SS8Q119 |
| 201 CONTINUE | SS8Q120 |
| C | SS8Q121 |
| C C3(I) NOW CONTAINS THE EIGENVECTOR WHICH MUST BE RE-ARRANGED | SS8Q122 |
| C ACCORDING TO THE ORDER DICTATED BY N1(I) BACK TO THE ORIGINAL | SS8Q123 |
| C ORDER. | SS8Q124 |
| C | SS8Q125 |
| 202 DO 230 I=1,N | SS8Q126 |
| I1 = N1(I) | SS8Q127 |
| N1(I) = I | SS8Q128 |
| 205 IF (I1-I) 210,230,210 | SS8Q129 |
| 210 D1 = C3(I1) | SS8Q130 |
| C3(I1) = C3(I) | SS8Q131 |
| C3(I) = D1 | SS8Q132 |
| K = N1(I1) | SS8Q133 |
| N1(I1) = I1 | SS8Q134 |
| I1 = K | SS8Q135 |
| GO TO 205 | SS8Q136 |
| 230 CONTINUE | SS8Q137 |
| C | SS8Q138 |
| IF (NTIME) 240,260,240 | SS8Q139 |
| 240 CALL STATUS (N1) | SS8Q140 |
| A1 = (N1(8) - IT1)*0.01 | SS8Q141 |
| WRITE (6,250) N,A1 | SS8Q142 |
| 250 FORMAT (1H0,////,42H THE TOTAL TIME FOR OBTAINING THE | SS8Q143 |
| 1 ,//, 25H EIGENVECTOR OF ORDER ,I3,6H IS ,E12.5, | SS8Q144 |
| 2 9H SECONDS.) | SS8Q145 |
| 260 N1(1) = 2 | SS8Q146 |
| C | SS8Q147 |
| 1000 RETURN | SS8Q148 |
| END | SS8Q149 |

CC = 00150

| | | |
|------|--|---------|
| | SUBROUTINE DISPLA (C, ITAG) | SS8R000 |
| C | | SS8R001 |
| C ** | THIS SUBROUTINE CALCULATES AND PRINTS DEFLECTIONS, CURVATURES, | SS8R002 |
| C ** | MOMENTS, SHEARS AND EDGE REACTIONS | SS8R003 |
| C | | SS8R004 |
| | DIMENSION F(15,25,25), FMAX(15), \$(3,4,4), C(150) | SS8R005 |
| | DIMENSION RA(2,25), RB(2,25), RLN(25) | SS8R006 |
| | DIMENSION A(3,3), B(3,3), D(3,3) | SS8R007 |
| | DIMENSION PKC(50), IGSPRX(50), IGSPRY(50) | SS8R008 |
| | DIMENSION PLINE(50), IDISLS(50), ITAGLS(50) | SS8R009 |
| | DIMENSION E(4,2,3,10,25) | SS8R010 |
| C | | SS8R011 |
| | COMMON / ARRAYS / F, FMAX | SS8R012 |
| | COMMON / VALUES / E | SS8R013 |
| | COMMON / PARAM / H(2250), PKC, IGSPRX, IGSPRY, | SS8R014 |
| 1 | PLINE, IDISLS, ITAGLS | SS8R015 |
| | COMMON / ABD / A, B, D | SS8R016 |
| | COMMON / GEOM / AA, BB, RR | SS8R017 |
| | COMMON / CNTROL / NCNT(7), IREACT, IOUT | SS8R018 |
| | COMMON / NUMBER / NPLYS, NTUX, NTVX, NTWX, NTUY, | SS8R019 |
| 1 | NTVY, NTWY, NMODES, NNUM(10), NPTSUP, | SS8R020 |
| 2 | NLNSPR, NUVW, NUV, NW | SS8R021 |
| C | | SS8R022 |
| | EQUIVALENCE (H(1),RA(1)),(H(51),RB(1)),(H(101),RLN(1)) | SS8R023 |
| | EQUIVALENCE (H(126),\$(1)) | SS8R024 |
| | DATA NMW / 'W' /, NMU / 'U' /, NMV / 'V' / | SS8R025 |
| C | | SS8R026 |
| | ITHERY = 1 | SS8R027 |
| 40 | DO 100 K=1,25 | SS8R028 |
| | DO 100 L=1,25 | SS8R029 |
| | DO 41 K1=1,3 | SS8R030 |
| | DO 41 K2=1,4 | SS8R031 |
| | DO 41 K3=1,4 | SS8R032 |
| 41 | \$(K1,K2,K3) = 0. | SS8R033 |
| | M = 1 | SS8R034 |
| | IF (ITAG .EQ. 3) M = 3 | SS8R035 |
| | IF (IOUT .EQ. 1 .AND. IREACT .EQ. 0) M=3 | SS8R036 |
| 42 | DO 80 N=M,3 | SS8R037 |
| | DO 80 I=1,NTWX | SS8R038 |
| | DO 80 J=1,NTWY | SS8R039 |
| | IF (N.EQ.1) II = (I-1)*NTUY + J | SS8R040 |
| | IF (N.EQ.2) II = NTUX*NTUY + (I-1)*NTVY + J | SS8R041 |
| | IF (N.EQ.3) II = NUV + (I-1)*NTWY + J | SS8R042 |
| | IF (N.EQ.3 .AND. ITAG.EQ.3) II = II - NUV | SS8R043 |
| | IF (N.EQ.1) GO TO 50 | SS8R044 |
| | IF (N.EQ.2) GO TO 60 | SS8R045 |
| | IF (N.EQ.3) GO TO 70 | SS8R046 |
| 50 | \$(N,2,1) = \$(N,2,1) + E(2,1,N,I,K)*E(1,2,N,J,L)*C(II) /AA | SS8R047 |
| | \$(N,3,1) = \$(N,3,1) + E(3,1,N,I,K)*E(1,2,N,J,L)*C(II) /AA/AA | SS8R048 |
| | \$(N,2,2) = \$(N,2,2) + E(2,1,N,I,K)*E(2,2,N,J,L)*C(II) /AA/BB | SS8R049 |
| | \$(N,1,3) = \$(N,1,3) + E(1,1,N,I,K)*E(3,2,N,J,L)*C(II) /BB/BB | SS8R050 |
| | \$(N,1,2) = \$(N,1,2) + E(1,1,N,I,K)*E(2,2,N,J,L)*C(II) /BB | SS8R051 |
| | \$(N,1,1) = \$(N,1,1) + E(1,1,N,I,K)*E(1,2,N,J,L)*C(II) | SS8R052 |
| | GO TO 80 | SS8R053 |
| 60 | \$(N,2,1) = \$(N,2,1) + E(2,1,N,I,K)*E(1,2,N,J,L)*C(II) /AA | SS8R054 |
| | \$(N,3,1) = \$(N,3,1) + E(3,1,N,I,K)*E(1,2,N,J,L)*C(II) /AA/AA | SS8R055 |

| | | | |
|------|--|-----------|---------|
| | $\$(N,2,2) = \$(N,2,2) + E(2,1,N,I,K)*E(2,2,N,J,L)*C(II)$ | /AA/BB | SS8R056 |
| | $\$(N,1,3) = \$(N,1,3) + E(1,1,N,I,K)*E(3,2,N,J,L)*C(II)$ | /BB/BB | SS8R057 |
| | $\$(N,1,2) = \$(N,1,2) + E(1,1,N,I,K)*E(2,2,N,J,L)*C(II)$ | /BB | SS8R058 |
| | $\$(N,1,1) = \$(N,1,1) + E(1,1,N,I,K)*E(1,2,N,J,L)*C(II)$ | | SS8R059 |
| | GO TO 80 | | SS8R060 |
| 70 | $\$(N,1,1) = \$(N,1,1) + E(1,1,N,I,K)*E(1,2,N,J,L)*C(II)$ | | SS8R061 |
| | IF (IOUT .EQ. 1 .AND. IREACT .EQ. 0) GO TO 80 | | SS8R062 |
| | $\$(N,2,1) = \$(N,2,1) + E(2,1,N,I,K)*E(1,2,N,J,L)*C(II)$ | /AA | SS8R063 |
| | $\$(N,3,1) = \$(N,3,1) + E(3,1,N,I,K)*E(1,2,N,J,L)*C(II)$ | /AA/AA | SS8R064 |
| | $\$(N,4,1) = \$(N,4,1) + E(4,1,N,I,K)*E(1,2,N,J,L)*C(II)$ | /AA/AA/AA | SS8R065 |
| | $\$(N,3,2) = \$(N,3,2) + E(3,1,N,I,K)*E(2,2,N,J,L)*C(II)$ | /AA/AA/BB | SS8R066 |
| | $\$(N,2,2) = \$(N,2,2) + E(2,1,N,I,K)*E(2,2,N,J,L)*C(II)$ | /AA/BB | SS8R067 |
| | $\$(N,2,3) = \$(N,2,3) + E(2,1,N,I,K)*E(3,2,N,J,L)*C(II)$ | /AA/BB/BB | SS8R068 |
| | $\$(N,1,4) = \$(N,1,4) + E(1,1,N,I,K)*E(4,2,N,J,L)*C(II)$ | /BB/BB/BB | SS8R069 |
| | $\$(N,1,3) = \$(N,1,3) + E(1,1,N,I,K)*E(3,2,N,J,L)*C(II)$ | /BB/BB | SS8R070 |
| | $\$(N,1,2) = \$(N,1,2) + E(1,1,N,I,K)*E(2,2,N,J,L)*C(II)$ | /BB | SS8R071 |
| 80 | CONTINUE | | SS8R072 |
| | $F(1,K,L) = \$(3,1,1)$ | | SS8R073 |
| | IF (IOUT .EQ. 1 .AND. IREACT .EQ. 0) GO TO 100 | | SS8R074 |
| | $F(2,K,L) = \$(1,1,1)$ | | SS8R075 |
| | $F(3,K,L) = \$(2,1,1)$ | | SS8R076 |
| | IF (IOUT .EQ. 2 .AND. IREACT .EQ. 0) GO TO 100 | | SS8R077 |
| | $EX = \$(1,2,1)$ | | SS8R078 |
| | $EY = \$(2,1,2) + \$(3,1,1)/RR$ | | SS8R079 |
| | $EXY = \$(1,1,2) + \$(2,2,1)$ | | SS8R080 |
| | $XK = -\$(3,3,1)$ | | SS8R081 |
| | IF (ITHRY .NE. 1) GO TO 85 | | SS8R082 |
| | $YK = \$(2,1,2)/RR - \$(3,1,3)$ | | SS8R083 |
| | $XYK = 2.*(\$(2,2,1)/RR - \$(3,2,2))$ | | SS8R084 |
| | GO TO 86 | | SS8R085 |
| 85 | $YK = -\$(3,1,3) - \$(3,1,1)/RR/RR$ | | SS8R086 |
| | $XYK = -2.*\$(3,2,2) - \$(1,1,2)/RR + \$(2,2,1)/RR$ | | SS8R087 |
| 86 | CONTINUE | | SS8R088 |
| | $F(4,K,L) = EX$ | | SS8R089 |
| | $F(5,K,L) = EY$ | | SS8R090 |
| | $F(6,K,L) = EXY$ | | SS8R091 |
| | $F(7,K,L) = XK$ | | SS8R092 |
| | $F(8,K,L) = YK$ | | SS8R093 |
| | $F(9,K,L) = XYK$ | | SS8R094 |
| | IF (IOUT .EQ. 3 .AND. IREACT .EQ. 0) GO TO 100 | | SS8R095 |
| 90 | $F(10,K,L) = B(1,1)*EX + B(1,2)*EY + B(1,3)*EXY + D(1,1)*XK + D(1,2)*YK$ | | SS8R096 |
| 1 | $+ D(1,3)*XYK$ | | SS8R097 |
| | $F(11,K,L) = B(1,2)*EX + B(2,2)*EY + B(2,3)*EXY + D(1,2)*XK + D(2,2)*YK$ | | SS8R098 |
| 1 | $+ D(2,3)*XYK$ | | SS8R099 |
| | $F(12,K,L) = B(1,3)*EX + B(2,3)*EY + B(3,3)*EXY + D(1,3)*XK + D(2,3)*YK$ | | SS8R100 |
| 1 | $+ D(3,3)*XYK$ | | SS8R101 |
| C ** | LET $\$(1,4,4) = MX, X$ | | SS8R102 |
| C ** | $\$(2,4,4) = MY, Y$ | | SS8R103 |
| C ** | $\$(3,4,4) = MXY, X$ | | SS8R104 |
| C ** | $\$(3,4,3) = MXY, Y$ | | SS8R105 |
| | $\$(1,4,4) = B(1,1)*\$(1,3,1) + B(1,2)*(\$(2,2,2) + \$(3,2,1)/RR)$ | | SS8R106 |
| 1 | $+ B(1,3)*(\$(1,2,2) + \$(2,3,1)) - D(1,1)*\$(3,4,1)$ | | SS8R107 |
| 2 | $+ D(1,2)*(\$(2,2,2)/RR - \$(3,2,3)) + D(1,3)*2.*\$(2,3,1)/RR$ | | SS8R108 |
| 3 | $- \$(3,3,2))$ | | SS8R109 |
| | $\$(2,4,4) = B(1,2)*\$(1,2,2) + B(2,2)*(\$(2,1,3) + \$(3,1,2)/RR)$ | | SS8R110 |
| 1 | $+ B(2,3)*(\$(1,1,3) + \$(2,2,2)) - D(1,2)*\$(3,3,2)$ | | SS8R111 |

| | | |
|-----|--|---------|
| 2 | + D(2,2)*(\$ (2,1,3)/RR-\$ (3,1,4)) | SS8R112 |
| 3 | + D(2,3)*2.*(\$ (2,2,2)/RR - \$ (3,2,3)) | SS8R113 |
| | \$ (3,4,4) = B(1,3)*\$ (1,3,1) + B(2,3)*(\$ (2,2,2)+\$ (3,2,1)/RR) | SS8R114 |
| 1 | + B(3,3)*(\$ (1,2,2)+\$ (2,3,1)) - D(1,3)*\$ (3,4,1) | SS8R115 |
| 2 | + D(2,3)*(\$ (2,2,2)/RR-\$ (3,2,3)) | SS8R116 |
| 3 | + D(3,3)*2.*(\$ (2,3,1)/RR-\$ (3,3,2)) | SS8R117 |
| | \$ (3,4,3) = B(1,3)*\$ (1,2,2) + B(2,3)*(\$ (2,1,3)+\$ (3,1,2)/RR) | SS8R118 |
| 1 | + B(3,3)*(\$ (1,1,3)+\$ (2,2,2)) - D(1,3)*\$ (3,3,2) | SS8R119 |
| 2 | + D(2,3)*(\$ (2,1,3)/RR-\$ (3,1,4)) | SS8R120 |
| 3 | + D(3,3)*2.*(\$ (2,2,2)/RR-\$ (3,2,3)) | SS8R121 |
| C | | SS8R122 |
| C | F(13,K,L) = QX = MX,X + MXY,Y | SS8R123 |
| C | F(14,K,L) = QY = MY,Y + MXY,X | SS8R124 |
| C | | SS8R125 |
| | F(13,K,L) = \$ (1,4,4) + \$ (3,4,3) | SS8R126 |
| | F(14,K,L) = \$ (2,4,4) + \$ (3,4,4) | SS8R127 |
| C | | SS8R128 |
| C | RA = QX + MXY,Y | SS8R129 |
| C | RB = QY + MXY,X | SS8R130 |
| C | | SS8R131 |
| | IF(K.EQ.1) RA(1,L) = - (F(13,K,L)+ \$ (3,4,3)) | SS8R132 |
| | IF(K.EQ.25) RA(2,L) = F(13,K,L)+ \$ (3,4,3) | SS8R133 |
| | IF(L.EQ.1) RB(1,K) = - (F(14,K,L)+ \$ (3,4,4)) | SS8R134 |
| | IF(L.EQ.25) RB(2,K) = F(14,K,L)+ \$ (3,4,4) | SS8R135 |
| 100 | CONTINUE | SS8R136 |
| C | | SS8R137 |
| C | TO NORMALIZE | SS8R138 |
| C | | SS8R139 |
| | KMAX = 14 | SS8R140 |
| | IF (IREACT .NE. 0) GO TO 101 | SS8R141 |
| | IF (IOUT .EQ. 1) KMAX = 1 | SS8R142 |
| | IF (IOUT .EQ. 2) KMAX = 3 | SS8R143 |
| | IF (IOUT .EQ. 3) KMAX = 9 | SS8R144 |
| 101 | CONTINUE | SS8R145 |
| | CALL NRMLIZ (1, KMAX) | SS8R146 |
| | WRITE (6,600) NMW, FMAX(1) | SS8R147 |
| 600 | FORMAT ('1THE ',A1,' DEFLECTIONS DIVIDED BY ',E15.6,'/10000 FOLLOW | SS8R148 |
| | 1') | SS8R149 |
| | CALL OUT (1) | SS8R150 |
| | I=IOUT | SS8R151 |
| | IF(I.EQ.1.OR.I.EQ.6.OR.I.EQ.7.OR.I.EQ.8) GO TO 150 | SS8R152 |
| | WRITE (6,600) NMU, FMAX(2) | SS8R153 |
| | CALL OUT (2) | SS8R154 |
| | WRITE (6,600) NMV, FMAX(3) | SS8R155 |
| | CALL OUT (3) | SS8R156 |
| | IF (IOUT .EQ. 2 .OR. IOUT .EQ. 3) GO TO 150 | SS8R157 |
| 220 | WRITE (6,680) FMAX(10) | SS8R158 |
| 680 | FORMAT ('1MX DIVIDED BY ',E15.6,'/10000 FOLLOWS') | SS8R159 |
| | CALL OUT (10) | SS8R160 |
| | WRITE (6,690) FMAX(11) | SS8R161 |
| 690 | FORMAT ('1MY DIVIDED BY ',E15.6,'/10000 FOLLOWS') | SS8R162 |
| | CALL OUT (11) | SS8R163 |
| | WRITE (6,700) FMAX(12) | SS8R164 |
| 700 | FORMAT ('1MXY DIVIDED BY ',E15.6,'/10000 FOLLOWS') | SS8R165 |
| | CALL OUT (12) | SS8R166 |
| | WRITE (6,710) FMAX(13) | SS8R167 |

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| 710 | FORMAT ('1QX DIVIDED BY ',E15.6,'/10000 FOLLOWS') | SS8R168 |
| | CALL OUT (13) | SS8R169 |
| | WRITE (6,720) FMAX(14) | SS8R170 |
| 720 | FORMAT ('1QY DIVIDED BY ',E15.6,'/10000 FOLLOWS') | SS8R171 |
| | CALL OUT (14) | SS8R172 |
| 150 | IF (IREACT .EQ. 0) GO TO 900 | SS8R173 |
| C ** | POINT SPRING REACTIONS | SS8R174 |
| | IF (NPTSUP .EQ. 0) GO TO 170 | SS8R175 |
| | DO 160 J=1,NPTSUP | SS8R176 |
| | K = IGSPRX(J) | SS8R177 |
| | L = IGSPRY(J) | SS8R178 |
| | FD = - F(1,K,L) * PKC(J) * FMAX(1) | SS8R179 |
| 160 | WRITE (6,650) K,L,FD | SS8R180 |
| 650 | FORMAT ('OTHE REACTION AT GRID POINT 'I3,', 'I3,' IS ',E15.7) | SS8R181 |
| 170 | CONTINUE | SS8R182 |
| | IF (NLNSPR .EQ. 0) GO TO 725 | SS8R183 |
| | DO 210 J=1,NLNSPR | SS8R184 |
| | IF (ITAGLS(J) .EQ. 2) GO TO 190 | SS8R185 |
| | L = IDISLS(J) | SS8R186 |
| | DO 180 K=1,25 | SS8R187 |
| 180 | RLN(K) = - F(1,K,L) * PLINE(J) * FMAX(1) | SS8R188 |
| | WRITE (6,660) L, (RLN(K), K=1,25) | SS8R189 |
| 660 | FORMAT ('OTHE REACTION OF THE LINE SPRING ALONG GRID LINE 'I3, | SS8R190 |
| 1 | ' PARALLEL TO THE X AXIS FOLLOWS'/(5E15.7)) | SS8R191 |
| | GO TO 210 | SS8R192 |
| 190 | K = IDISLS(J) | SS8R193 |
| | DO 200 L=1,25 | SS8R194 |
| 200 | RLN(L) = - F(1,K,L) * PLINE(J) * FMAX(1) | SS8R195 |
| | WRITE (6,670) K, (RLN(L), L=1,25) | SS8R196 |
| 670 | FORMAT ('OTHE REACTION OF THE LINE SPRING ALONG GRID LINE 'I3, | SS8R197 |
| 1 | ' PARALLEL TO THE Y AXIS FOLLOWS'/(5E15.7)) | SS8R198 |
| 210 | CONTINUE | SS8R199 |
| C ** | CORNER REACTIONS | SS8R200 |
| 725 | F(12,1,1) = -2. * F(12,1,1) * FMAX(12) | SS8R201 |
| | F(12,1,25) = 2. * F(12,1,25) * FMAX(12) | SS8R202 |
| | F(12,25,1) = 2. * F(12,25,1) * FMAX(12) | SS8R203 |
| | F(12,25,25) = -2. * F(12,25,25) * FMAX(12) | SS8R204 |
| | WRITE (6,730) (RA(1,L), L=1,25) | SS8R205 |
| 730 | FORMAT(1H1'THE REACTIONS ALONG X=0 FOLLOW'/(1H07E16.7)) | SS8R206 |
| | WRITE (6,740) (RA(2,L), L=1,25) | SS8R207 |
| 740 | FORMAT(1H0/' THE REACTIONS ALONG X=A FOLLOW'/(1H07E16.7)) | SS8R208 |
| | WRITE (6,750) (RB(1,K), K=1,25) | SS8R209 |
| 750 | FORMAT(1H0/' THE REACTIONS ALONG Y=0 FOLLOW'/(1H07E16.7)) | SS8R210 |
| | WRITE (6,760) (RB(2,K), K=1,25) | SS8R211 |
| 760 | FORMAT(1H0/' THE REACTIONS ALONG Y=B FOLLOW'/(1H07E16.7)) | SS8R212 |
| | WRITE (6,770) F(12,1,1) | SS8R213 |
| 770 | FORMAT(1H0/' THE CORNER REACTION AT 0,0 IS' E16.7) | SS8R214 |
| | WRITE (6,780) F(12,25,1) | SS8R215 |
| 780 | FORMAT(1H /' THE CORNER REACTION AT A,0 IS' E16.7) | SS8R216 |
| | WRITE (6,790) F(12,1,25) | SS8R217 |
| 790 | FORMAT(1H /' THE CORNER REACTION AT 0,B IS' E16.7) | SS8R218 |
| | WRITE (6,800) F(12,25,25) | SS8R219 |
| 800 | FORMAT(1H /' THE CORNER REACTION AT A,B IS' E16.7) | SS8R220 |
| 900 | IF (IOUT .GE. 3) CALL STRESS | SS8R221 |
| 999 | RETURN | SS8R222 |
| | END | SS8R223 |

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|------|---|---------|
| | SUBROUTINE PRINT | SS8S000 |
| C ** | | SS8S001 |
| C ** | THIS SUBROUTINE CONTROLS THE PRINTING OF GRID POINT OUTPUT. | SS8S002 |
| C ** | | SS8S003 |
| | DIMENSION T(150,150) | SS8S004 |
| | DIMENSION U(50,50), Q(150), S(150) | SS8S005 |
| | DIMENSION WORK1(150), WORK2(150), ITIME(12), TIME(50) | SS8S006 |
| | DOUBLE PRECISION T | SS8S007 |
| C | | SS8S008 |
| | COMMON U | SS8S009 |
| | COMMON / BLOCK / T | SS8S010 |
| | COMMON / CNTROL / ID, IFLAGB, I\$(7), KEY | SS8S011 |
| | COMMON / NUMBER / N\$(6), NTWY, NMODES, M\$(12), NUVW, NUV, NW, ITX, ITY | SS8S012 |
| | COMMON / \$TIME / TIME, ITIME | SS8S013 |
| | COMMON / PARAM / Q, S, WORK1, WORK2 | SS8S014 |
| | COMMON / MODES / MM(50), NN(50) | SS8S015 |
| C | | SS8S016 |
| | IF (KEY .EQ. 1) GO TO 10 | SS8S017 |
| | IF (KEY .EQ. 2) GO TO 20 | SS8S018 |
| | IF (KEY .EQ. 3) GO TO 30 | SS8S019 |
| C ** | STATIC DEFLECTION | SS8S020 |
| 10 | CONTINUE | SS8S021 |
| | WRITE (6,48) (WORK1(I), I=1,NUVW) | SS8S022 |
| 48 | FORMAT ('!THE CONTRIBUTIONS OF THE SERIES TERMS TO DEFLECTION FOLLOW'/(1X,10E12.4)) | SS8S023 |
| | CALL DISPLA (WORK1, 1) | SS8S024 |
| | GO TO 1000 | SS8S025 |
| C ** | FREE VIBRATION | SS8S026 |
| 20 | CONTINUE | SS8S027 |
| | DO 9990 I=1,NUVW | SS8S028 |
| | IF (WORK1(I) .LE. .5) GO TO 9990 | SS8S029 |
| | ISTART = I | SS8S030 |
| | GO TO 9991 | SS8S031 |
| 9990 | CONTINUE | SS8S032 |
| 9991 | IFIN = ISTART + NMODES - 1 | SS8S033 |
| | DO 90 I=ISTART,IFIN | SS8S034 |
| | WRITE (6,60) WORK1(I), MM(I), NN(I), (T(I,J), J=1,NUVW) | SS8S035 |
| 60 | FORMAT ('!THE FREQUENCY IS ',E16.7,' CPS. FOR M = ',I2,', N = ', | SS8S036 |
| | 1 I2,',.'/!OTHE CONTRIBUTIONS OF THE SERIES TERMS FOLLOW!/' | SS8S037 |
| | 2 (1X,10E12.4)) | SS8S038 |
| | DO 70 J=1,NUVW | SS8S039 |
| 70 | WORK2(J) = T(I,J) | SS8S040 |
| | CALL DISPLA (WORK2, 2) | SS8S041 |
| 90 | CONTINUE | SS8S042 |
| | GO TO 1000 | SS8S043 |
| C ** | BUCKLING | SS8S044 |
| 30 | CONTINUE | SS8S045 |
| | DO 200 I=1,IFLAGB | SS8S046 |
| | BIG = 0.1 | SS8S047 |
| | NSAVE = 0 | SS8S048 |
| | DO 180 J=1,NW | SS8S049 |
| | IF (ABS (U(I,J)) .LE. BIG) GO TO 180 | SS8S050 |
| | BIG = ABS (U(I,J)) | SS8S051 |
| | NSAVE = J | SS8S052 |
| 180 | WORK2(J) = U(I,J) | SS8S053 |
| | M = ITX | SS8S054 |
| | | SS8S055 |

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|--|---------|
| N = ITY | SS8S056 |
| IF (NSAVE .EQ. 1) GO TO 6 | SS8S057 |
| DO 5 J=2,NSAVE | SS8S058 |
| IF (N+1-ITY .GE. NTWY) GO TO 4 | SS8S059 |
| N = N+1 | SS8S060 |
| GO TO 5 | SS8S061 |
| 4 N = ITY | SS8S062 |
| M = M+1 | SS8S063 |
| 5 CONTINUE | SS8S064 |
| 6 CONTINUE | SS8S065 |
| WRITE (6,190) WORK1(I), M, N, (WORK2(J), J=1,NW) | SS8S066 |
| 190 FORMAT ('OTHE BUCKLING EIGENVALUE IS' E16.7,' FOR M ='I3,', N =' | SS8S067 |
| 1 I3,','/'OTHE CONTRIBUTIONS OF THE SERIES TERMS FOR W FOLL | SS8S068 |
| 20W'/(1X,10E12.4)) | SS8S069 |
| CALL DISPLA (WORK2, 3) | SS8S070 |
| 200 CONTINUE | SS8S071 |
| 1000 CONTINUE | SS8S072 |
| CALL STATUS (ITIME) | SS8S073 |
| ET = .01*ITIME(8) - TIME(1) | SS8S074 |
| MINUTE = INT (ET/60.) | SS8S075 |
| SEC = AMOD (ET , 60.) | SS8S076 |
| ISEC = SEC | SS8S077 |
| WRITE (6,66) MINUTE, ISEC | SS8S078 |
| 66 FORMAT ('OTHE EXECUTION TIME FOR THIS PROBLEM WAS ',I3,' MINUTES, | SS8S079 |
| 1',I2,' SECONDS.') | SS8S080 |
| RETURN | SS8S081 |
| END | SS8S082 |

CC = 00083

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SUBROUTINE STRESS
C **
C ** THIS SUBROUTINE CALCULATES STRESSES AND STRAINS.
C **
  DIMENSION F(15,25,25), FMAX(5)
  DIMENSION A(3,3), B(3,3), D(3,3), Z(41)
  DIMENSION THETA(40), THICK(40), C11(40), C22(40)
  DIMENSION C12(40), C66(40), ANGCK(3,10), MCHK(3)
  DIMENSION EC(3,40), ET(3,40), SIG(5)
  DIMENSION SIGS(5), SMAR(5), EPSN(5), EPSS(5)

  COMMON / ARRAYS / F, FMAX
  COMMON / ABD / A, B, D, RHAB, THETA, THICK, C11, C22,
1 C66, C12, EC, ET, ANGCK, MCHK, Z
  COMMON / CNTROL / I$(5), IMATL, J$(2), IOUT
  COMMON / NUMBER / NPLYS

  DATA X/'X'//, Y/'Y'//, YO/'LOW'//, UP/'UPP'//
  DATA $X/'X-'//, $Y/'Y-'//, $Z /'XY'//, $1/'1-'//, $2/'2-'//, $3 /'12'//
  DATA SIG(1)/'NORM'//, SIG(2)/'AL S'//, SIG(3)/'TRES'//
  DATA SIG(4)/'SES '//, SIG(5)/' '//
  DATA SIGS(1)/'SHEA'//, SIGS(2)/'R S'//, SIGS(3)/'TRES'//
  DATA SIGS(4)/'SES '//, SIGS(5)/' '//
  DATA SMAR(1)/'MARG'//, SMAR(2)/'INS '//, SMAR(3)/'OF S'//
  DATA SMAR(4)/'AFET'//, SMAR(5)/'Y'//
  DATA EPSN(1)/'NORM'//, EPSN(2)/'AL S'//, EPSN(3)/'TRAI'//
  DATA EPSN(4)/'NS '//, EPSN(5)/' '//
  DATA EPSS(1)/'SHEA'//, EPSS(2)/'R S'//, EPSS(3)/'TRAI'//
  DATA EPSS(4)/'NS '//, EPSS(5)/' '//

  FMIN = 100.
  VAL = 1.
10 FORMAT ('0',25F5.2)
  I = IOUT
  IF(I.EQ.4.OR.I.EQ.6.OR.I.EQ.7.OR.I.EQ.8) GO TO 51
  WRITE (6,20) X, FMAX(4)
  CALL OUT ( 4)
20 FORMAT ('1THE MIDDLE SURFACE STRAIN IN THE ',A1,' DIRECTION DIVIDE
1D BY ',E15.6,'/10000 FOLLOWS')
  WRITE (6,20) Y, FMAX(5)
  CALL OUT ( 5)
  WRITE (6,30) FMAX(6)
  CALL OUT ( 6)
30 FORMAT ('1THE MIDDLE SURFACE SHEAR STRAIN DIVIDED BY ',E15.6,
1 '/10000 FOLLOWS')
  WRITE (6,40) X, FMAX(7)
  CALL OUT ( 7)
40 FORMAT ('1THE CURVATURE IN THE ',A1,' DIRECTION DIVIDED BY ',
1 E15.6,'/10000 FOLLOWS')
  WRITE (6,40) Y, FMAX(8)
  CALL OUT ( 8)
  WRITE (6,50) FMAX(9)
  CALL OUT ( 9)
50 FORMAT ('1THE TWIST CURVATURE DIVIDED BY ',E15.6,'/10000 FOLLOWS')
  IF ( IOUT .EQ. 3 ) GO TO 999
51 IF ( IMATL .EQ. 1 .OR. IMATL .EQ. 4 ) GO TO 150

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| C ** SOLID LAMINATE | SS8T056 |
| IF (IOUT .LT. 7) GO TO 999 | SS8T057 |
| NP = NPLYS + 1 | SS8T058 |
| DO 100 N=1,NP | SS8T059 |
| ITEST = 0 | SS8T060 |
| J = N | SS8T061 |
| IF (Z(N) .GE. 0) J = N - 1 | SS8T062 |
| IF (C11(J) .LE. 10.) GO TO 100 | SS8T063 |
| DO 60 JJ=1,3 | SS8T064 |
| J3 = JJ+3 | SS8T065 |
| J6 = JJ+6 | SS8T066 |
| DO 60 K=1,25 | SS8T067 |
| DO 60 L=1,25 | SS8T068 |
| 60 F(JJ,K,L) = FMAX(J3)*F(J3,K,L) + Z(N)*FMAX(J6)*F(J6,K,L) | SS8T069 |
| 70 IF (ITEST .NE. 0) J = N | SS8T070 |
| ANG = THETA(J) | SS8T071 |
| CALL ROTATE (10, 1, ANG) | SS8T072 |
| CALL NRMLIZ (10, 12) | SS8T073 |
| CALL MARGIN (10, 13, J) | SS8T074 |
| WRITE(6,80)J,THETA(J),EPSN,\$1,FMAX(10) | SS8T075 |
| CALL OUT (10) | SS8T076 |
| WRITE(6,80)J,THETA(J),EPSN,\$2,FMAX(11) | SS8T077 |
| CALL OUT (11) | SS8T078 |
| WRITE(6,80)J,THETA(J),EPSS,\$3,FMAX(12) | SS8T079 |
| CALL OUT (12) | SS8T080 |
| WRITE(6,80)J,THETA(J),SMAR,\$1,VAL | SS8T081 |
| CALL OUT (13) | SS8T082 |
| WRITE(6,80)J,THETA(J),SMAR,\$2,VAL | SS8T083 |
| CALL OUT (14) | SS8T084 |
| WRITE(6,80)J,THETA(J),SMAR,\$3,VAL | SS8T085 |
| CALL OUT (15) | SS8T086 |
| 80 FORMAT ('1FOR LAYER ',I2,' (THETA = ',F6.2,'), THE ',4A4,A1, ' IN THE ',A2,' DIRECTION DIVIDED BY ',E15.6,'/10000 FOLLOW') | ISS8T087 |
| CALL SEARCH (J,1,13,15,MH,KH,LH,IH,NH,FMIN) | SS8T088 |
| IF (ABS(Z(N)) .GT. 1.E-4) GO TO 100 | SS8T089 |
| IF (ABS(THETA(N) - THETA(N-1)) .LT. .01) GO TO 100 | SS8T090 |
| IF (ITEST .EQ. 1) GO TO 100 | SS8T091 |
| ITEST = 1 | SS8T092 |
| GO TO 70 | SS8T093 |
| 100 CONTINUE | SS8T094 |
| IF (MH .EQ. 13) \$=\$1 | SS8T095 |
| IF (MH .EQ. 14) \$=\$2 | SS8T096 |
| IF (MH .EQ. 15) \$=\$3 | SS8T097 |
| WRITE (6,110) \$, IH, KH, LH, FMIN | SS8T098 |
| 110 FORMAT ('1THE MINIMUM MARGIN OF SAFETY OCCURS FOR A STRAIN IN THE ',A2,' DIRECTION IN LAYER ',I2,' AT X = ',I2,' Y = ',I2,' ITS VALUE IS ',F5.2) | SS8T099 |
| GO TO 999 | SS8T100 |
| C ** ISOTROPIC OR SANDWICH | SS8T101 |
| 150 CONTINUE | SS8T102 |
| DO 600 N=1,2 | SS8T103 |
| SUR = YO | SS8T104 |
| IF (N.EQ.2) SUR = UP | SS8T105 |
| IF (IMATL .EQ. 4) GO TO 160 | SS8T106 |
| I = 1 | SS8T107 |
| J = N | SS8T108 |
| | SS8T109 |
| | SS8T110 |
| | SS8T111 |

| | |
|---|---------|
| GO TO 170 | SS8T112 |
| 160 I=1 | SS8T113 |
| J=1 | SS8T114 |
| IF (N.EQ.1) GO TO 170 | SS8T115 |
| I = 3 | SS8T116 |
| J = 4 | SS8T117 |
| 170 CONTINUE | SS8T118 |
| C ** CALCULATE COMBINED STRAINS IN PANEL AXES. | SS8T119 |
| DO 180 JJ=1,3 | SS8T120 |
| J3 = JJ+3 | SS8T121 |
| J6 = JJ+6 | SS8T122 |
| DO 180 K=1,25 | SS8T123 |
| DO 180 L=1,25 | SS8T124 |
| 180 F(JJ,K,L) = FMAX(J3)*F(J3,K,L) + Z(J) * FMAX(J6)*F(J6,K,L) | SS8T125 |
| IF (IOUT .LT. 4 .OR. IOUT .EQ. 7) GO TO 240 | SS8T126 |
| C ** CALCULATE COMBINED STRESSES IN PANEL AXES. | SS8T127 |
| DO 190 K=1,25 | SS8T128 |
| DO 190 L=1,25 | SS8T129 |
| F(10,K,L) = C11(I) * F(1,K,L) + C12(I) * F(2,K,L) | SS8T130 |
| F(11,K,L) = C12(I) * F(1,K,L) + C22(I) * F(2,K,L) | SS8T131 |
| 190 F(12,K,L) = C66(I) * F(3,K,L) | SS8T132 |
| CALL NRMLIZ (10, 12) | SS8T133 |
| WRITE(6,200) SIG ,SUR,\$X,FMAX(10) | SS8T134 |
| CALL OUT (10) | SS8T135 |
| WRITE(6,200) SIG ,SUR,\$Y,FMAX(11) | SS8T136 |
| CALL OUT (11) | SS8T137 |
| WRITE(6,200) SIGS,SUR,\$Z,FMAX(12) | SS8T138 |
| CALL OUT (12) | SS8T139 |
| 200 FORMAT ('1THE ',4A4,A1,' ON THE ',A3,'ER SURFACE IN THE ',A2, | SS8T140 |
| 1 ' DIRECTION DIVIDED BY ',E15.6,'/10000 FOLLOW') | SS8T141 |
| 240 CONTINUE | SS8T142 |
| IF (IOUT .LT. 7) GO TO 600 | SS8T143 |
| IF (IMATL .EQ. 4) GO TO 400 | SS8T144 |
| C ** ISOTROPIC | SS8T145 |
| CALL NRMLIZ (1, 3) | SS8T146 |
| CALL MARGIN (1, 10, I) | SS8T147 |
| WRITE(6,200) EPSN,SUR,\$X,FMAX(1) | SS8T148 |
| CALL OUT (1) | SS8T149 |
| WRITE(6,200) EPSN,SUR,\$Y,FMAX(2) | SS8T150 |
| CALL OUT (2) | SS8T151 |
| WRITE(6,200) EPSS,SUR,\$Z,FMAX(3) | SS8T152 |
| CALL OUT (3) | SS8T153 |
| WRITE(6,200) SMAR,SUR,\$X,VAL | SS8T154 |
| CALL OUT (10) | SS8T155 |
| WRITE(6,200) SMAR,SUR,\$Y,VAL | SS8T156 |
| CALL OUT (11) | SS8T157 |
| WRITE(6,200) SMAR,SUR,\$Z,VAL | SS8T158 |
| CALL OUT (12) | SS8T159 |
| CALL SEARCH (I,N,10,12,MH,KH,LH,IH,NH,FMIN) | SS8T160 |
| GO TO 600 | SS8T161 |
| C ** SANDWICH | SS8T162 |
| 400 NCHK = MCHK(I) | SS8T163 |
| DO 500 NN=1,NCHK | SS8T164 |
| ANG = ANGCK(I,NN) | SS8T165 |
| CALL ROTATE (10, 1, ANG) | SS8T166 |
| CALL NRMLIZ (10, 12) | SS8T167 |

| | |
|--|---------|
| CALL MARGIN (10, 13, I) | SS8T168 |
| CALL SEARCH (I, NN, 13, 15, MH, KH, LH, IH, NH, FMIN) | SS8T169 |
| WRITE(6,410) ANG, EPSN, SUR, \$1, FMAX(10) | SS8T170 |
| CALL OUT (10) | SS8T171 |
| WRITE(6,410) ANG, EPSN, SUR, \$2, FMAX(11) | SS8T172 |
| CALL OUT (11) | SS8T173 |
| WRITE(6,410) ANG, EPSS, SUR, \$3, FMAX(12) | SS8T174 |
| CALL OUT (12) | SS8T175 |
| WRITE(6,410) ANG, SMAR, SUR, \$1, VAL | SS8T176 |
| CALL OUT (13) | SS8T177 |
| WRITE(6,410) ANG, SMAR, SUR, \$2, VAL | SS8T178 |
| CALL OUT (14) | SS8T179 |
| WRITE(6,410) ANG, SMAR, SUR, \$3, VAL | SS8T180 |
| CALL OUT (15) | SS8T181 |
| 410 FORMAT ('1FOR THETA = ', F6.2, ', THE ', 4A4, A1, ' ON THE ', A3, | SS8T182 |
| 1'ER SURFACE IN THE ', A2, ' DIRECTION DIVIDED BY ', | SS8T183 |
| 2 E15.6, '/10000 FOLLOW') | SS8T184 |
| 500 CONTINUE | SS8T185 |
| 600 CONTINUE | SS8T186 |
| IF (IOUT .LT. 7) GO TO 999 | SS8T187 |
| IF (IMATL .EQ. 4) GO TO 620 | SS8T188 |
| IF (MH .EQ. 10) \$=\$1 | SS8T189 |
| IF (MH .EQ. 11) \$=\$2 | SS8T190 |
| IF (MH .EQ. 12) \$=\$3 | SS8T191 |
| IF (NH .EQ. 1) SUR = YO | SS8T192 |
| IF (NH .EQ. 2) SUR = UP | SS8T193 |
| WRITE (6,610) \$, SUR, KH, LH, FMIN | SS8T194 |
| 610 FORMAT ('1THE MINIMUM MARGIN OF SAFETY OCCURS FOR A STRAIN IN THE | SS8T195 |
| 1', A2, ' DIRECTION ON THE ', A3, 'ER SURFACE AT X = ', I2, ', Y = ', I2, | SS8T196 |
| 2 ' ', ' ' ITS VALUE IS ', F6.2) | SS8T197 |
| GO TO 999 | SS8T198 |
| 620 ANG = ANGCK(IH, NH) | SS8T199 |
| IF (MH .EQ. 13) \$=\$1 | SS8T200 |
| IF (MH .EQ. 14) \$=\$2 | SS8T201 |
| IF (MH .EQ. 15) \$=\$3 | SS8T202 |
| WRITE (6,630) \$, ANG, IH, KH, LH, FMIN | SS8T203 |
| 630 FORMAT ('1THE MINIMUM MARGIN OF SAFETY OCCURS FOR A STRAIN IN THE | SS8T204 |
| 1', A2, ' DIRECTION AT AN ANGLE THETA OF ', F6.2, ' DEGREES IN LAYER ' | SS8T205 |
| 2 ', I2, ' ', ' ' IT IS LOCATED AT X = ', I2, ', Y = ', I2, ', AND HAS A VAL | SS8T206 |
| 3UE OF ', F6.2) | SS8T207 |
| 999 RETURN | SS8T208 |
| END | SS8T209 |

CC = 00210

| | |
|---|---------|
| SUBROUTINE ROTATE (M, MX, ANG) | SS8U000 |
| C ** | SS8U001 |
| C ** THIS SUBROUTINE PERFORMS A TRANSFORMATION OF COORDINATES | SS8U002 |
| C ** FROM THETA = 0. TO THETA = ANG . | SS8U003 |
| C ** | SS8U004 |
| DIMENSION F(15,25,25) | SS8U005 |
| C | SS8U006 |
| COMMON / ARRAYS / F | SS8U007 |
| C | SS8U008 |
| M1 = M+1 | SS8U009 |
| M2 = M+2 | SS8U010 |
| MX1 = MX+1 | SS8U011 |
| MX2 = MX+2 | SS8U012 |
| A = ANG * .0174533 | SS8U013 |
| C = COS(A) | SS8U014 |
| S = SIN(A) | SS8U015 |
| C2 = C*C | SS8U016 |
| S2 = S*S | SS8U017 |
| SC = S*C | SS8U018 |
| DO 10 K=1,25 | SS8U019 |
| DO 10 L=1,25 | SS8U020 |
| F(M,K,L) = F(MX,K,L)*C2 + F(MX1,K,L)*S2 + F(MX2,K,L)*SC | SS8U021 |
| F(M1,K,L) = F(MX,K,L)*S2 + F(MX1,K,L)*C2 + F(MX2,K,L)*SC | SS8U022 |
| 10 F(M2,K,L) = -2.*SC*(F(MX,K,L) - F(MX1,K,L)) + F(MX2,K,L)*(C2-S2) | SS8U023 |
| RETURN | SS8U024 |
| END | SS8U025 |

CC = 00026

| | | |
|------|--|---------|
| | SUBROUTINE NRMLIZ (M1, M2) | SS8V000 |
| C ** | | SS8V001 |
| C ** | THE INPUT ARRAYS ARE NORMALIZED BY THEIR LARGEST VALUES. | SS8V002 |
| C ** | | SS8V003 |
| | DIMENSION F(15,25,25), FMAX(15) | SS8V004 |
| C | | SS8V005 |
| | COMMON / ARRAYS / F, FMAX | SS8V006 |
| C | | SS8V007 |
| | DO 30 M=M1,M2 | SS8V008 |
| | FMAX(M) = F(M,1,1) | SS8V009 |
| | DO 10 K=1,25 | SS8V010 |
| | DO 10 L=1,25 | SS8V011 |
| | FD = ABS (F(M,K,L)) | SS8V012 |
| | IF (FD .GT. FMAX(M)) FMAX(M) = FD | SS8V013 |
| 10 | CONTINUE | SS8V014 |
| | IF (ABS (FMAX(M)) .LT. 1.E-10) FMAX(M) = 1. | SS8V015 |
| | DO 20 K=1,25 | SS8V016 |
| | DO 20 L=1,25 | SS8V017 |
| 20 | F(M,K,L) = F(M,K,L) / FMAX(M) | SS8V018 |
| 30 | CONTINUE | SS8V019 |
| | RETURN | SS8V020 |
| | END | SS8V021 |

CC = 00022

| | | |
|------|--|---------|
| | SUBROUTINE MARGIN (MSTRN, MMAR, LAY) | SS8W000 |
| C ** | | SS8W001 |
| C ** | THIS SUBROUTINE CALCULATES MARGINS OF SAFETY ACCORDING | SS8W002 |
| C ** | TO THE MAXIMUM STRAIN THEORY. | SS8W003 |
| C ** | | SS8W004 |
| | DIMENSION F(15,25,25), FMAX(15), EA(3), ET(3,40), EC(3,40) | SS8W005 |
| C | | SS8W006 |
| | COMMON / ARRAYS / F, FMAX | SS8W007 |
| | COMMON / ABD / DUM(268), EC, ET | SS8W008 |
| C | | SS8W009 |
| | DO 10 M=1,3 | SS8W010 |
| | I= M+MSTRN -1 | SS8W011 |
| | J= M+MMAR -1 | SS8W012 |
| | DO 10 K=1,25 | SS8W013 |
| | DO 10 L=1,25 | SS8W014 |
| | EA(M) = ET(M,LAY) | SS8W015 |
| | IF (F(I,K,L) .LE. 0.) EA(M) = EC(M,LAY) | SS8W016 |
| | F(J,K,L) = 9.0 | SS8W017 |
| | IF (F(I,K,L) .NE. 0.) F(J,K,L) = EA(M)/F(I,K,L)/FMAX(I) - 1. | SS8W018 |
| | IF (F(J,K,L) .GE. 9.99) F(J,K,L) = 9.98 | SS8W019 |
| | IF (F(J,K,L) .LE.-9.99) F(J,K,L) =-9.98 | SS8W020 |
| 10 | CONTINUE | SS8W021 |
| | RETURN | SS8W022 |
| | END | SS8W023 |

CC = 00024

| | | |
|-----|---|---------|
| | SUBROUTINE REDUCE (NOPT,V,Z1,Z2,Z3,Z4,WORK1,WORK2,NUV,NW) | SS8W025 |
| | DIMENSION V(150,150), Z1(100,100), Z2(100,50), Z3(50,100), | SS8W026 |
| 1 | Z4(50,50), WORK1(150), WORK2(150) | SS8W027 |
| C | | SS8W028 |
| | DO 10 I=1,NUV | SS8W029 |
| | DO 10 J=1,NUV | SS8W030 |
| 10 | Z1(I,J) = V(I,J) | SS8W031 |
| | DO 20 I=1,NUV | SS8W032 |
| | DO 20 J=1,NW | SS8W033 |
| 20 | Z2(I,J) = V(I,J+NUV) | SS8W034 |
| | DO 30 I=1,NW | SS8W035 |
| | DO 30 J=1,NUV | SS8W036 |
| 30 | Z3(I,J) = V(I+NUV,J) | SS8W037 |
| | CALL GJINV (Z1,NUV,0,IER,WORK1,WORK2,100) | SS8W038 |
| | CALL SWITCH (Z1, NUV, 50, 1., 0.) | SS8W039 |
| | CALL YOSFEM (2,Z1,NUV,NUV,50,Z2,NW,50,V,WORK1) | SS8W040 |
| | CALL YOSFEM (3,Z3,NW,NUV,25,Z2,NW,50,Z4,WORK1) | SS8W041 |
| | DO 40 I=1,NW | SS8W042 |
| | DO 40 J=1,NW | SS8W043 |
| 40 | Z4(I,J) = V(I+NUV,J+NUV) - Z4(I,J) | SS8W044 |
| 50 | DO 60 I=1,NW | SS8W045 |
| | DO 60 J=1,NW | SS8W046 |
| 60 | V(I,J) = Z4(I,J) | SS8W047 |
| 999 | RETURN | SS8W048 |
| | END | SS8W049 |

CC = 00025

| | | |
|----|--|---------|
| | SUBROUTINE FLEX | SS8Y000 |
| C | THIS SUBROUTINE CALCULATES THE FLEXIBILITY MATRIX AT THE | SS8Y001 |
| C | DESIRED POINTS. | SS8Y002 |
| | COMMON / FLEXBL / XP(50), YP(50) | SS8Y003 |
| | COMMON / ZWORK / W(50,50), EM(50,50), FL(50,50), | SS8Y004 |
| 1 | W1(50), W2(50) | SS8Y005 |
| | COMMON / VALUES / E(4,2,3,10,25) | SS8Y006 |
| | COMMON / NUMBER / NPLYS, NTX, N\$(2), NTY, M\$(15), MAT, NUV, NW | SS8Y007 |
| | COMMON / CNTROL / I\$(14), IFLEX | SS8Y008 |
| | COMMON / ARRAYS / V(150,150) | SS8Y009 |
| | DO 10 I=1,NW | SS8Y010 |
| | DO 10 J=1,NW | SS8Y011 |
| 10 | W(I,J) = V(I,J) | SS8Y012 |
| | CALL GJINV (W, NW, 0, IER, W1, W2, 50) | SS8Y013 |
| | DO 20 II=1,IFLEX | SS8Y014 |
| | I = XP(II)*24 + 1 | SS8Y015 |
| | J = YP(II)*24 + 1 | SS8Y016 |
| | IF (I.LT.1) I=1 | SS8Y017 |
| | IF (J.LT.1) J=1 | SS8Y018 |
| | IF (I.GT.24) I=24 | SS8Y019 |
| | IF (J.GT.24) J=24 | SS8Y020 |
| | IP1 = I + 1 | SS8Y021 |
| | JP1 = J + 1 | SS8Y022 |
| | DELX = XP(II)*24. - (I-1) | SS8Y023 |
| | DELY = YP(II)*24. - (J-1) | SS8Y024 |
| | DO 20 L = 1,NTX | SS8Y025 |
| | DO 20 K = 1,NTY | SS8Y026 |
| | JJ = NTY*(L-1) + K | SS8Y027 |
| | EVX = E(1,1,3,L,I)*(1.-DELX) + E(1,1,3,L,IP1)*DELX | SS8Y028 |
| | EVY = E(1,2,3,K,J)*(1.-DELY) + E(1,2,3,K,JP1)*DELY | SS8Y029 |
| | EM(II,JJ) = EVX * EVY | SS8Y030 |
| 20 | CONTINUE | SS8Y031 |
| | DO 60 II=1,IFLEX | SS8Y032 |
| | DO 40 JJ=1,NW | SS8Y033 |
| | W1(JJ) = 0. | SS8Y034 |
| | DO 30 KK=1,NW | SS8Y035 |
| 30 | W1(JJ) = W1(JJ) + W(JJ,KK) * EM(II,KK) | SS8Y036 |
| 40 | CONTINUE | SS8Y037 |
| | DO 50 LL=1,IFLEX | SS8Y038 |
| | FL(II,LL) = 0. | SS8Y039 |
| | DO 50 KK=1,NW | SS8Y040 |
| 50 | FL(II,LL) = FL(II,LL) + EM(LL,KK) * W1(KK) | SS8Y041 |
| 60 | CONTINUE | SS8Y042 |
| | WRITE (6,70) | SS8Y043 |
| 70 | FORMAT ('1FLEXIBILITY MATRIX') | SS8Y044 |
| | DO 90 I=1,IFLEX | SS8Y045 |
| | WRITE (6,80) I, (FL(I,J), J=1,IFLEX) | SS8Y046 |
| 80 | FORMAT ('0ROW',I3//('1P6E16.6')) | SS8Y047 |
| 90 | CONTINUE | SS8Y048 |
| | RETURN | SS8Y049 |
| | END | SS8Y050 |

CC = 00051

| | | |
|------|---|---------|
| | SUBROUTINE KDF (BUCKNX) | SS8Z000 |
| C | | SS8Z001 |
| C | COMPUTES AXIAL BUCKLING NX FOR IMPERFECT ANISOTROPIC CYLINDERS | SS8Z002 |
| C | | SS8Z003 |
| | DIMENSION AS(3,3), BS(3,3), DS(3,3), W1(3), W2(3) | SS8Z004 |
| | COMMON / ABD / A(3,3), B(3,3), D(3,3) | SS8Z005 |
| | COMMON / GEOM / AA, BB, RR, S\$(4), MU | SS8Z006 |
| | COMMON / CUBE / P1, P2, P3, P4, ROOT | SS8Z007 |
| | DIMENSION ITIME(12) | SS8Z008 |
| | DIMENSION ATAU(20), AMDA(20) | SS8Z009 |
| | REAL MU | SS8Z010 |
| C | | SS8Z011 |
| | FAC = 100 | SS8Z012 |
| | RHO = .707 | SS8Z013 |
| | DO 10 I=1,3 | SS8Z014 |
| | DO 10 J=1,3 | SS8Z015 |
| | 10 AS(I,J) = A(I,J) | SS8Z016 |
| | CALL GJINV (AS, 3, 0, IER, W1, W2, 3) | SS8Z017 |
| C ** | AS = A**-1 | SS8Z018 |
| | DO 20 I=1,3 | SS8Z019 |
| | DO 20 J=1,3 | SS8Z020 |
| | 20 BS(I,J) = - B(I,J) | SS8Z021 |
| | CALL YOSFEM (2, AS, 3, 3, 3, BS, 3, 3, D, W1) | SS8Z022 |
| C | BS = - A**-1 * B | SS8Z023 |
| | CALL YOSFEM (3, B, 3, 3, 3, BS, 3, 3, DS, W1) | SS8Z024 |
| | DO 30 I=1,3 | SS8Z025 |
| | DO 30 J=1,3 | SS8Z026 |
| | 30 DS(I,J) = D(I,J) + DS(I,J) | SS8Z027 |
| C | DS = D - B * A**-1 * B | SS8Z028 |
| | GAM = 1./SQRT(AS(2,2)*DS(1,1)) | SS8Z029 |
| | ALP = DS(1,1)*GAM | SS8Z030 |
| | BET = BS(2,1)*GAM | SS8Z031 |
| | IMAX = 10 | SS8Z032 |
| | TAUO = 0. | SS8Z033 |
| | FTAU = 10. | SS8Z034 |
| | 40 DO 100 I=1,IMAX | SS8Z035 |
| | ATAU(I) = TAUO + I/FTAU | SS8Z036 |
| | TAU = ATAU(I) | SS8Z037 |
| | D12 = DS(1,1)*RHO**4 + (2.*DS(1,2) + 4.*DS(3,3)) *RHO**2*TAU**2 | SS8Z038 |
| 1 | + DS(2,2)*TAU**4 | SS8Z039 |
| | A11 = AS(2,2)*RHO**4 + (2.*AS(1,2) + AS(3,3)) *RHO**2*TAU**2 | SS8Z040 |
| 1 | + AS(1,1)*TAU**4 | SS8Z041 |
| | A13 = AS(2,2)*81.*RHO**4 + (2.*AS(1,2) + AS(3,3)) *9.*RHO**2 | SS8Z042 |
| 1 | * TAU**2 + AS(1,1)*TAU**4 | SS8Z043 |
| | A21 = -2.*AS(2,3)*RHO**3*TAU - 2.*AS(1,3)*RHO*TAU**3 | SS8Z044 |
| | A22 = -A21 | SS8Z045 |
| | A23 = 2.*AS(2,3)*27.*RHO**3*TAU + 2.*AS(1,3)*3.*RHO*TAU**3 | SS8Z046 |
| | B11 = BS(2,1)*RHO**4 + (BS(1,1) + BS(2,2) - 2.*BS(3,3)) *RHO**2 | SS8Z047 |
| 1 | * TAU**2 + BS(1,2)*TAU**4 | SS8Z048 |
| | B11P = B11 - 2.*RHO*RHO/GAM | SS8Z049 |
| | B22 = (BS(3,1) - 2.*BS(2,3)) * RHO**3*TAU + (BS(3,2) | SS8Z050 |
| 1 | - 2.*BS(1,3)) * RHO*TAU**3 | SS8Z051 |
| | C1 = RHO*RHO + (1.-2.*RHO*RHO*BET)**2/4./RHO/RHO | SS8Z052 |
| | D1 = A11*A11 - A21*A21 | SS8Z053 |
| | D3 = A13*A13 - A23*A23 | SS8Z054 |
| | A1 = D12 + ((A11*B11P - A22*B22) * B11P + (A11*B22 - A22*B11P) | SS8Z055 |

| | | |
|-----|--|---------|
| 1 | * B22) / D1 | SS8Z056 |
| | A2 = 4.*ALP*RHO*RHO/GAM | SS8Z057 |
| | A3 = 4.*MU*RHO*RHO*TAU*TAU* (A11*B11P - A22*B22) *C1/D1 | SS8Z058 |
| | A4 = MU*ALP* (1. - 2.*RHO*RHO*BET) *TAU*TAU | SS8Z059 |
| | A5 = 4.*MU*MU*RHO**4*TAU**4*C1*C1* (A11/D1 + A13/D3) | SS8Z060 |
| | P1 = A2 | SS8Z061 |
| | P2 = - (A1 + 2.*A2*C1 + A4) | SS8Z062 |
| | P3 = 2.*A1*C1 + A2*C1*C1 + A4*C1 + A3 | SS8Z063 |
| | P4 = - (A1*C1*C1 + A3*C1 + A5) | SS8Z064 |
| | CALL CUBIC | SS8Z065 |
| | AMDA(I) = ROOT | SS8Z066 |
| 100 | CONTINUE | SS8Z067 |
| | CALL MIN (AMDA, IMAX, IMIN) | SS8Z068 |
| | IF (IMAX .EQ. 20) GO TO 200 | SS8Z069 |
| | TAUO = ATAU(IMIN) - .1 | SS8Z070 |
| | IMAX = 20 | SS8Z071 |
| | FTAU = 100 | SS8Z072 |
| | GO TO 40 | SS8Z073 |
| 200 | CONTINUE | SS8Z074 |
| | FAC = AMDA(IMIN) | SS8Z075 |
| | TAU = ATAU(IMIN) | SS8Z076 |
| 50 | BUCKNX = 2.*ALP*FAC/RR | SS8Z077 |
| | PBUCK = 2.*RR*BUCKNX*3.14159 | SS8Z078 |
| | WRITE (6,600) RHO, TAU, FAC, BUCKNX, PBUCK | SS8Z079 |
| 600 | FORMAT ('OIMPERFECTION SENSITIVITY ANALYSIS FOR FULL CYLINDER -- | SS8Z080 |
| | 1 RHO, TAU, LAMBDA-CR, NX-CR, P-CR'/' ' ',5E20.6) | SS8Z081 |
| | RETURN | SS8Z082 |
| | END | SS8Z083 |

CC = 00084

| | | |
|-----|---|----------|
| | SUBROUTINE CUBIC | SS8\$000 |
| C | SOLVES A CUBIC POLYNOMIAL FOR THE REAL ROOT BY NEWTON-RAPHSON | SS8\$001 |
| | COMMON / CUBE / P1, P2, P3, P4, Y | SS8\$002 |
| | X = 1 | SS8\$003 |
| | I = 0 | SS8\$004 |
| 1 | F = P1*X*X*X + P2*X*X + P3*X + P4 | SS8\$005 |
| | I = I + 1 | SS8\$006 |
| | FP = 3.*P1*X*X + 2.*P2*X + P3 | SS8\$007 |
| | Y = X - F/FP | SS8\$008 |
| | IF (ABS(1-Y/X).LE. .001) GO TO 10 | SS8\$009 |
| | X = Y | SS8\$010 |
| | IF (I .LT. 10) GO TO 1 | SS8\$011 |
| 10 | CONTINUE | SS8\$012 |
| | A = P1 | SS8\$013 |
| | B = P1*Y + P2 | SS8\$014 |
| | C = P1*Y*Y + P2*Y + P3 | SS8\$015 |
| | DISC = B*B - 4.*A*C | SS8\$016 |
| | IF (DISC) 20,30,30 | SS8\$017 |
| 20 | WRITE (6,70) | SS8\$018 |
| 70 | FORMAT ('OOTHER TWO ROOTS ARE COMPLEX') | SS8\$019 |
| | GO TO 100 | SS8\$020 |
| 30 | X1 = (-B + SQRT(DISC)) /2./A | SS8\$021 |
| | X2 = (-B - SQRT(DISC)) /2./A | SS8\$022 |
| | Y = AMIN1 (Y,X1,X2) | SS8\$023 |
| 100 | CONTINUE | SS8\$024 |
| | RETURN | SS8\$025 |
| | END | SS8\$026 |

CC = 00027

| | | |
|------|---|---------|
| | SUBROUTINE OUT (N) | SS8/000 |
| C ** | | SS8/001 |
| C ** | THIS SUBROUTINE PUTS THE ARRAYS OF OUTPUT IN A FORM FOR | SS8/002 |
| C ** | EFFICIENT WRITING. | SS8/003 |
| C ** | | SS8/004 |
| | COMMON / ARRAYS / F(15,25,25), FMAX(15), LIST(625) | SS8/005 |
| C | | SS8/006 |
| | DO 10 K=1,25 | SS8/007 |
| | DO 10 L=1,25 | SS8/008 |
| | J = (K-1) * 25 + L | SS8/009 |
| 10 | LIST(J) = F(N,K,L) * 10000 | SS8/010 |
| | WRITE (6,20) LIST | SS8/011 |
| 20 | FORMAT ('0',25I5) | SS8/012 |
| | RETURN | SS8/013 |
| | END | SS8/014 |

CC = 00015

| | |
|-----------------------------------|---------|
| SUBROUTINE MIN (VEC, N, IMIN) | SS8 000 |
| DIMENSION VEC(N) | SS8 001 |
| SMALL = 10. | SS8 002 |
| DO 10 I=1,N | SS8 003 |
| IF (SMALL .LT. VEC(I)) GO TO 10 | SS8 004 |
| SMALL = VEC(I) | SS8 005 |
| IMIN = I | SS8 006 |
| 10 CONTINUE | SS8 007 |
| RETURN | SS8 008 |
| END | SS8 009 |

CC = 00010